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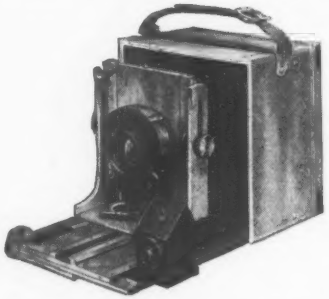

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THE OXFORD UNIVERSITY EXPEDITION TO BRITISH GUIANA: *A paper read at the Evening Meeting of the Society on 5 May 1930, by*

MAJOR R. W. G. HINGSTON

A BIOLOGICAL expedition to British Guiana was the conception of the Oxford University Exploration Club. The field was certain to be a very fertile one. British investigators had strangely avoided it, yet it was sure to be teeming with problems, a forest storehouse of innumerable secrets, some of which we hoped to solve.

Though so neglected by British naturalists, the Americans had shown greater enterprise. Several expeditions under Dr. William Beebe had worked in the district around Bartica, where they had amassed large collections and had added much to our knowledge of the country. We hoped both to continue and extend their work. Our intention was to study both the fauna and the flora. We were not so much concerned with collections as with matters connected with field observation, such as habits, instincts, life-histories, behaviour, and problems relating to ecology.

In two directions especially we hoped to extend the field of the Americans. Dr. Beebe and his staff were mainly zoologists. We wished in addition to work at botany, and particularly the vegetation of the deep forest away from the ordinary route of travel. Also, and this was perhaps our main objective, we hoped to get up into the tree roof, and find out something of the life in the green canopy which would lie spread out over our heads. This roof we thought must be teeming with life which had hitherto escaped scientific investigation. Dr. Beebe in his several expeditions to the Colony must often have raised his eyes longingly to it. He writes in one of his many books: "Yet another continent of life remains to be discovered, not upon the earth, but 100 to 200 feet above it, extending over thousands of square miles of South America. At present we know almost nothing about it. Up to now gravitation and tree-trunks swarming with terrible ants have kept us at bay, and of the tree-top life we have obtained only unconnected facts and specimens. There awaits a rich harvest for the naturalist who overcomes the obstacles—gravitation, thorns, ants, rotten trunks—and mounts to the summits of the jungle trees." It was in order to glean a little of this harvest that the expedition came into existence.

We were unable to make any progress without material assistance from societies and friends. Our requests for aid were received most sympathetically. The objective appeared to be novel enough and the promise of results sufficiently hopeful to secure for the enterprise all it needed. The Trustees of the Percy Sladen Memorial Fund supported us in the most generous possible manner and defrayed half the expenses of the expedition. The Royal Society made a grant from the funds at its disposal for scientific investigations. The Royal Geographical Society found us a surveyor, equipped him with instruments, and paid his expenses. The Royal Botanic Gardens at Kew attached to us a member of its botanical staff, equipped him and maintained him in the field. Oxford University backed the enterprise both officially and materially. Contributions also came from members of the expedition and other private persons interested in it. Several firms came to our aid and either lent us or presented us with necessary equipment, and the cost of the Atlantic passage was considerably reduced by the generosity of the Harrison Line. I am glad to have this opportunity of expressing my thanks for all this generous and valuable assistance, and particularly to the Trustees of the Percy Sladen Memorial Fund, through whose aid the expedition was alone made possible.

The interest taken in us by the Colonial Office helped largely to make our way smooth, and we are much indebted for both kindness and material assistance from the Government of British Guiana.

In addition to myself the party consisted of ten persons: N. Y. Sandwith and P. W. Richards, botanists; O. W. Richards and J. E. Duffield, entomologists; E. M. Nicholson and B. D. Nicholson, ornithologists; F. E. Buckland, zoologist; L. Slater, surveyor; S. T. A. Livingstone-Learmonth, taxidermist; M. J. Cresswell, wireless operator. In the Colony we were joined by T. A. W. Davis, an officer of the Forest Department.

We sailed from London on July 19. A brief stay at Trinidad gave us an opportunity of meeting the staff of the Imperial College of Tropical Agriculture. They entertained us in a royal manner and showed us all the workings of the institution. We reached Georgetown on August 5, not particularly impressed by the low-lying buildings, the many miles of uninviting mud-flats, and the broad expanse of soupy water.

Official guidance came to us immediately. The Acting-Governor of the Colony, His Excellency the Hon. C. D. Douglas-Jones, C.M.G., had, previous to our arrival, made arrangements with the Government Departments to assist us. Boats were placed free at our disposal; we were given free transport on Government vessels and railways; we were assisted with medical supplies. Dr. Parry, the Lord Bishop of the Colony, took us under his hospitable roof. The Hon. Mr. B. R. Wood, Conservator of Forests, did much to make our enterprise successful. He detailed Mr. T. A. W. Davis, one of his most experienced forest officers, to accompany our party. He placed at our disposal and paid the expenses of some of his trained botanical assistants. He secured for us the best Indians that the colony could provide, and helped us in many other directions, not least in protecting us from that flourishing industry, the fleecing of the unsuspecting foreigner. It is difficult to find words that will properly express our thanks for all this help and kindness.

Five days were spent in Georgetown making necessary preliminary arrange-

Moraballi creek

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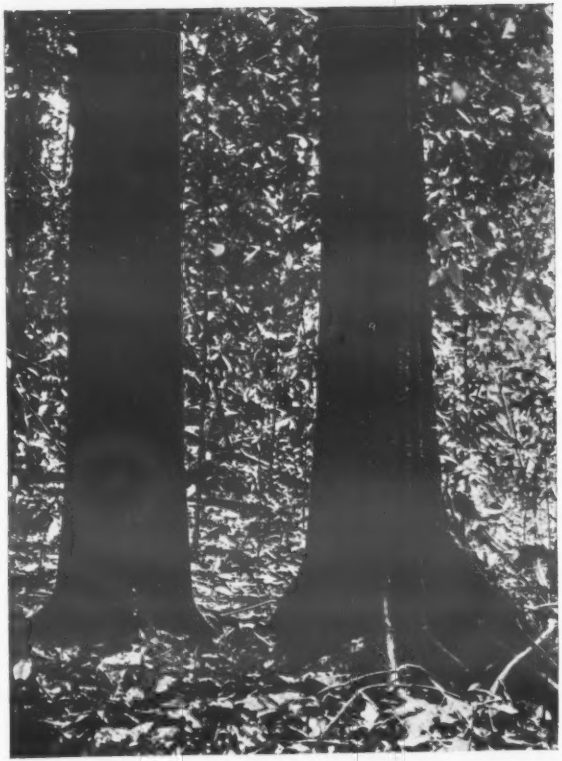
Buttresses round base of giant tree



Fluted trunks of Yaruru trees

ments. We left on August 10 and travelled by river steamer to Bartica, at the junction of the Essequibo and Mazaruni rivers. Bartica is the jumping-off place for the interior. Its most striking feature is the fleet of boats that take parties of gold-diggers and diamond-seekers on their quest for wealth into the high country.

The next day we transferred to open boats driven by Archimedes motors. In these we continued up the Essequibo river towards the Moraballi creek. We were in a huge river, some 2 to 3 miles broad, that flowed between walls of forest. The vegetation was magnificent, tangled and luxuriant. It clothed every square foot of river-bank and every islet or small lump of rock that projected above the stream. Here we saw many fine trees in flower which excited both the enthusiasm and greed of our botanists. For the bird men there were tree-swallows, herons, and terns. For the insect observers there was a migration of butterflies persistently moving in thousands across the river.

About 15 miles above Bartica we reached the entrance to the Moraballi creek. Here we plunged straight into the wall of vegetation and found ourselves in a narrow sinuous waterway not more than 40 or 50 feet wide. We had gone straight into the primitive forest where branches and creepers brushed against our boats and interlaced themselves above our heads, converting the waterway into an arcade. On either side of us were huge Mora trees and graceful palms. Aerial roots hung down on us like stalactites, and creepers spread themselves above and around us like the cordage and rigging of a ship. The water was a peculiar coffee-colour caused by the pigment from the decaying leaves of the Wallaba tree. Half-hidden logs and fallen trunks of trees to some extent obstructed this narrow waterway. A few rounded rocks appeared in places. But without any more serious trouble than the cutting away of pendent branches we followed this forest tunnel for some 2 miles from the main river, where we found on the right bank of the creek a site suitable for camp.

A preliminary investigation of the locality showed that we had hit on a part of the forest eminently suited to our biological objectives. We decided to establish there a permanent camp. Having chosen an elevated sandy area quite close to the creek bank, we spent some days digging ourselves in. A clearing was made, some 2000 square yards in area, almost all the trees large and small being levelled to the ground. A hundred trees or more may have come down in order to let the necessary light into our camp. Suitable shelters were then built, being made of forked sticks and poles, over which large tarpaulins were spread. We had separate shelters for sleeping, feeding, cooking, and working; also shelters for the men, the apparatus, and the stores. We slept in hammocks ranged side by side, each enclosed in a mosquito net.

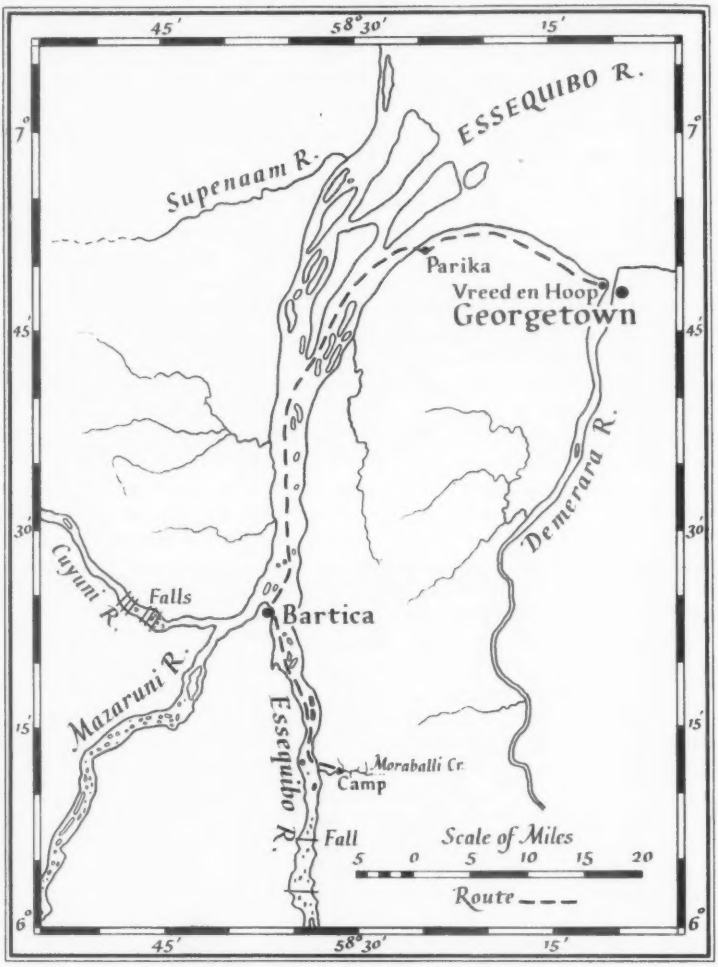
The plot of ground on which we found ourselves was covered over completely with dark, dense, luxuriant forest. It seemed to be the very kind of thing we wanted. That is to say, it was primitive, almost untouched forest, where Nature's operations had been little interfered with, and which had stood for probably geological periods on the same spot and in much the same state. Had we gone to some more open region, say along the river-bank or in secondary growth, we might have made more voluminous collections; but what we wanted was the real primitive forest where the trees and plants were in their most

Fluted trunks of Yaruru trees

Buttresses round base of giant tree

natural associations, and where animal life, though perhaps less abundant, would at the same time be more rare.

The forest presented itself to us in this particular area as a dense assemblage of straight trees. Some were monsters, 20 feet in girth, with column-like trunks



The Lower Essequibo, British Guiana

and expanded bases which made them not unlike the massive pillars that support a cathedral dome. These large ones were somewhat thinly scattered, perhaps some 50 to 100 feet from one another. The vast majority were saplings or half-grown trees, with straight, leafless, branchless trunks, all packed together in

riotous competition, struggling to get their heads into the roof. Not one had a branch until it neared the canopy, when it usually divided into a simple fork at a height of about 70 feet. The crowns of the trees were relatively small and for the most part oval or globular. Many had expanded buttressed bases. Some had huge caverns inside their trunks where obnoxious creatures were accustomed to hide. Bush-ropes of every degree of thickness spread themselves about in this forest of poles. They encircled the pillars with serpentine coils and reached out in pendent loops that stretched from trunk to trunk. Mosses, epiphytes, lichens, ferns, crowded the trees in bewildering confusion. Overhead the tree-tops made a green roof, while the fallen vegetation covered the floor with a thick soft carpet of mould. All through the forest there were glittering lights, bright spots, streaks and luminous patches, where shafts of sunlight breaking through the roof illuminated the underlying foliage which reflected them like sheets of glass. It often looked as if a multitude of mirrors were suspended in the vista of green. On every side was the richest fertility, and in the prostrate trunks and rotting leaf-mould was equal evidence of death and decay. The silence, the gloom, the stillness, the luxuriance, were the most impressive features of the place.

There was not much obstruction to movement in this forest. There was no need to cut through dense undergrowth or entanglements. What checked one was usually a fallen tree-trunk, or a pile of roots, or an impassable swamp. Nor was one much troubled with thorny vegetation. Here and there was a palm with a thorny stem, but one was never held up, as in many other forests, by a barrier of prickly plants. We soon found how easy it was to lose oneself in the forest owing to the sameness of the vegetation everywhere and the absence of any horizon or conspicuous landmark. If one wandered 50 feet from a trail one might get back only with the greatest difficulty. In the forest the compass is the best guide, and the careful man will never leave a trail without snapping the saplings as he walks along so as to enable him to find his way back.

The soil on which we camped was sandy, a very special advantage in this swampy region. The land in the neighbourhood was distinctly undulating, and offered different types of forest for investigation. Much of it lay at or below creek-level, and these parts were impassable swamps. In a few places there were running streams, along the course of which patches of igneous rock pushed themselves through the carpet of leaves. The creek was one of the class of "blackwater creeks," that is to say, its water was clear but stained brown with vegetable material. Though distinctly coffee in colour, it was fit and pleasant to drink.

Three days made camp fairly comfortable. It was our business to be as comfortable as circumstances permitted. We were not out for adventures or excitements. Our objective was concentrated scientific observation, the maximum of work in the minimum of time. Hence our business was to be as well fed and well housed as possible, and anything in the nature of accident, hardship, or adventure would be only a tribute to bad management or organization. I may give as examples of our attempts at domesticity that we always, if we wished it, had a daily hot bath, and always had our meals off a clean tablecloth. Little things like these mean much in the wilds and add zest and volume to scientific work.

The detailed exploration of this patch of forest then began in real earnest. My business here is not to deal with biological questions, but to enter on those practical matters which come under the head of forest exploration. There are several points worth putting on record with a view of assisting another party that might sometime wish to continue our work.

The botanists, Sandwith and Paul Richards, attended to the varied types of vegetation. Sandwith's mode of collecting was novel and successful. His equipment was not the trowel and vasculum, but a retinue of Indians with cutlasses and axes. Nor was it a kindly peaceful undertaking, but rather a strenuous destructive business accompanied with a roar of crashing timber that always told us where the botanists were at work. Few flowers were to be seen in the gloomy forest. Their home was in the roof, 100 feet above our heads. First a tree in flower had to be found. This was done by searching the forest floor for petals that had fallen down from the roof. The canopy had then to be studied with binoculars in the hope of detecting which tree was in flower. If very fortunate, the botanist might hit on the tree, but more likely he could only decide that it was one of three or four. Then the Indians would come along. A platform would be built around the tree to a higher level than the broad buttressed base. Standing on it, the men would attack the trunk, hewing a great wedge out of opposite sides of it. Then, as the tree showed signs of falling, they would leap from the platform and rush from the danger zone. The tree would then come down with a roar, bursting the bush-ropes that bound it to its neighbours, and smashing other trees before it as it fell. Often the bush-ropes would keep it suspended. Then the rigging would have to be slashed through and obstructing trees would have to be cut down. At times a dozen or more trees would be felled and a large clearing made in the forest before the botanist got his particular flower. But there was often compensation for such prolonged labour. Flowering bush-ropes, new tree-top orchids, mosses, ferns, fungi, and other things which could never be known of from the ground, would be gathered from the fallen chaos. Here too was a chance for the entomologist. He would often find strange things in the fallen vegetation which never frequented the forest floor. More rarely, the confusion would yield larger creatures. A tree-top snake or lizard might be found in it, a huge sloth or a canopy-frequenting rodent might scramble out of the prostrate pile.

Paul Richards concentrated on other types of plants. The ferns, mosses, and lichens came under his particular care. He also attacked special problems in ecology. The forest trees of the Colony being so important economically, Sandwith paid particular attention to them. Some of the largest and most useful and most abundant of them had been identified with no certainty. His material should help to throw light on the timber possibilities of those vast forests.

A visitor to our camp was Mr. Martyn, an officer of the Agricultural Department of the Colony. He was an authority on fungi, and spent a fortnight with us collecting material from the rich supply available in the forest. He very kindly included his collections in ours, all of which have gone for identification to Kew.

Our botanists were relieved of much tedious routine through our having in camp a trained botanical presser placed at our disposal by the Forest Depart-

ment. Mr. Subrayon undertook this work, drying, pressing, and poisoning the specimens, a duty that needs unremitting attention in so excessively moist a climate. Every hour of sunshine must be utilized by day, and it is a wise thing at night to continue the drying over a row of hurricane lamps.

Ornithology came under the care of the Nicholsons. They attended particularly to observations on the habits, behaviour and distribution of the birds. Equipped with powerful artillery glasses, they could get the best view possible of the tree-top inhabitants. But much of their work was done from the observation-posts which we established in the tree-roof. Our Indian hunter Stoll brought in specimens daily, and these were skinned, either by Livingstone-Learmonth or by Jothan, one of our Indians, who after a brief training made a splendid taxidermist.

Entomology was in the experienced hands of O. W. Richards, assisted by Duffield. The field was immense and the material endless. Richards interested himself particularly in the habits of tropical bees and wasps, some of which made very peculiar nests. Duffield devoted himself to animal ecology. He took one large tree under detailed observation, collecting everything from its foot to its highest branches and noting the interdependence of creature on creature in this original field of study. The collections made by Richards and Duffield were immense, and even to the last day in our camp new forms of life were continually coming in. By following the British Museum instructions we lost no entomological specimens from mould. I joined with the entomologists and interested myself in those forms of animal protection which are associated with the name of Professor Poulton.

Buckland and Livingstone-Learmonth were taxidermists. They built a skinning shelter with poles and palm-leaves, and drying-shelves roofed over with canvas. Every day specimens came to their hands, birds and mammals to be skinned, reptiles to be pickled; whatever we or our Indians found went straight to the taxidermist's shed. There were days when they were overwhelmed with the quantity of material, and times when they were driven almost to distraction by seeing the damp, the mould, and the insects destroying their tedious work. Buckland also attended particularly to mammals which he caught in snap-traps or by digging pits for them. Bats were shot or were captured in cylindrical nets placed over holes in hollow trees.

Slater made our camp his headquarters for his several journeys to survey the Essequibo. Acting on the advice of the local government, he carried out a triangulation between Bartica and the first falls on the Essequibo.

Davis helped the botanists in all departments of their work. His experience of the forest, his exact knowledge of the various trees, and his zeal for everything connected with botany were a valuable stimulus for us all. To me he was a universal assistant, directing the camp and managing the labour. Also in the latter half of the expedition he took over the mammal and reptile collections and performed much of the taxidermy.

One of our first and most important duties was to have trails and lines cut through the forest so as to give free access to it and allow us to see better what it contained. It is not easy to walk quietly or see clearly in the forest. But a trail makes an open line before one. It permits one to move noiselessly and to see many creatures skipping across it whose presence would without it have passed

unobserved. We must have made at least 12 miles of trail before we left this particular area. They became so numerous around our camp and so frequently intersected that it was not difficult to get lost in the maze. Broad roads in the forest, some 12 feet in width, make the best of all localities for observation. Large clearings of 100 yards or so in breadth are also well worth the labour of making. The open space gives a splendid field for observation. Plants which are not found in the natural forest soon spring up in these open clearings, and many animals get attracted to them which we do not meet with elsewhere. I think that one of the first necessities for a study of the forest is to make a network of narrow trails together with clearings and roads.

Our chief trouble in the forest came from damp. The heat caused no discomfort. The temperature scarcely exceeded 80°. The days were never uncomfortably hot. A single blanket was necessary at night. The sun had no unpleasant effects. We never wanted a fan or a punkah, and the whole day could be spent in the forest without even the protection of a hat. Damp, on the other hand, caused some discomfort. For the first month, during the wet season, the air was constantly almost saturated with moisture; heavy rain fell daily; every leaf in the forest dripped. A visit to it meant getting soaked to the skin. Nothing would dry in the humid atmosphere, and we got accustomed to starting each day in the wet clothes of the evening before. Our specimens rotted, boots and everything made of leather got quickly covered in green mould. Our photographic plates refused to dry. It was a relief when mid-September came and less humid conditions began to appear. The rain then came in more occasional showers, though there was usually a fall every day. The sun grew warmer, the continuous drip ceased from the foliage, the dead leaves beneath one's feet began to crackle, and we could manage to get clothing dry and keep it dry all day in the bush. We often hear of discomforts in tropical forests, but seldom, if ever, is it insisted on that the chief nuisance and discomfort is damp.

In round figures the annual rainfall is about 100 inches. The average shade temperature is 80°. The average humidity is 85. The sun shines from four to six hours daily. Thunderstorms are very frequent and are associated with torrential rain.

What was very noticeable in the forest was the almost complete absence of wind. Our sleeping and feeding shelters were without sides, yet we were never troubled with gusts of wind. Papers could be left night and day lying on the tables, yet would never be blown away. The tree-tops at times shook violently enough; the clouds might be seen scudding across the sky, while everything on the forest floor remained perfectly peaceful and still. Leaves are not much shaken to the ground; they are beaten down by the force of the rain.

The forest harboured a few pests. The most unpleasant was the *bête rouge*, the tiny larva of a harvest-mite. This almost invisible creature burrows into the softer areas of one's skin, often in considerable numbers. As a consequence of this infestation one's legs get covered with red irritable spots that feel like an attack of nettlerash. It is a troublesome pest in that it gives one sleepless nights, and if the bites happen to get infected they turn into nasty sores. *Bête rouge* has a special capacity for getting into tight and restricted places. Nothing they like better than to squeeze underneath a waist-belt or beneath a bandage round an ulcerated leg. They seemed to be worse on the sunny days that follow occa-

sional showers. Almost every mammal and bird in the forest show signs of being attacked by this pest. Fortunately, a considerable degree of immunity against them develops after one month. Their attacks, though as numerous as ever, produce infinitely less irritation. Kamberol is a good preventative against them, and a saturated solution of common salt a fairly efficient cure.

Ticks were another distinct nuisance. They sit on the forest vegetation waiting for a favourable chance to cling to some creature that happens to pass. Many in this way get on to one's body and fasten themselves to the skin by a spear-like proboscis. In order to deal with these two pests a daily delousing operation was necessary. Each evening it was advisable to go over one's body carefully and pick off the crop of *bête rouge* and ticks that had been collected during the day. The penalty for neglecting this important operation was an itching and scratching night.

Mosquitoes, though fairly abundant in dark and swampy places, were distinctly less troublesome than I had anticipated. But they proved a nuisance to observers who had to keep quite still, and especially when spending a night on a perch in the forest canopy. Malaria is the chief disease likely to be contracted, but there is little fear of it in the actual forest. The dangerous places are the villages and encampments on the banks of the large rivers. No one was bitten by a poisonous snake; nor had we any experience of vampire bats.

A minor and peculiar unpleasantness is the feeling of being so completely shut in. There is no horizon. On every side is a wall of vegetation. One feels as if confined in a prison. This grows on one after a few months. Then there follows a strange sense of relief on getting once more on an open river, and enjoying the feeling of spaciousness and freedom after being, as it were, imprisoned in the bush.

Any one working in this damp forest must be prepared for serious photographic disappointment. To begin with, the light in the forest is tantalizing. Every window in the overhead canopy lets in a narrow stream of sunlight which ruins an exposure for a dark object on the forest floor. In Europe we expose when the sun comes out; in the forest we must wait, sometimes for hours, until it gets behind a cloud. Each subsequent stage has its particular snag. Films stick to the aprons in the developing tanks; they blister or melt in the fixative solution; they refuse to dry in the humid atmosphere; and even when carefully packed away they make a splendid medium for the growth of moulds. Prolonged exposures, development in the early hours of morning, the use of freezing mixtures and hardeners, the employment of a hypo-killer, are the points we found worth special attention in dealing with these particular snags.

Living for four months in the forest made it advisable to get fresh food. One of our Indians was detailed as a hunter, supplied daily with gun and cartridges, and sent into the forest to shoot game. He proved very successful where a European would find little or nothing. His best animals were tapir, with flesh like that of horse; paca, which reminded one of pork; and forest deer which made quite good venison. Also he brought in many agoutis, and on most days excellent birds. He almost kept the camp supplied with a sufficiency of fresh meat. It would be useful to a party continuing this work to know how much meat a patch of forest can produce. We were camped in it for 105 days, during which time the hunter brought in 1 Tapir, 1 Red Deer, 3 Paca, 27 Agouti, 18 Pigmy Agouti,

18 Curassow, 33 Guan, 30 Great Tinamou, 32 Small Tinamou, 16 Partridges, and 7 Trumpeters.

Fish, on the other hand, was very scarce. All the creek supplied were a few small Kurumaya and two large Haimara. I was surprised at the scarcity of edible plants and fruits. All this varied and luxuriant vegetation produced very little fit to eat. A small yellowish fruit, *Redia*, had a flavour like a rancid grape; a few Sawari nuts were a little like Brazil nuts; the heart of the common Turu palm could be made into a kind of cabbage. But these forms of food were scarcely worth collecting, and the traveller in this bush must place no reliance on the expectation of finding either green vegetables or fruits.

A week after reaching our camp site we were in a position to start on our main objective, the attempt to get into the tree-roof and find out what kind of life existed in it. A word is necessary on the nature of this roof. From written descriptions I was led to imagine that the canopy was more of a real roof than we found to be the case in this particular area. The creepers and bush-ropes that passed from tree-crown to tree-crown were not dense enough to make a roof anything like the roof of a house. The crowns stood out more separately than I had expected. Perhaps there is more interlacing into an overhead carpet in other parts of the equatorial regions. The sky was not by any means completely hidden. Here and there were windows, skylights in the canopy, through which the sunlight streamed to illuminate the underlying floor. There seemed to be a distinct limitation of growth at a height of 30 to 40 feet. Many species of trees appeared unable to raise their heads above that particular level. As a consequence, at that height the forest was more open and offered more favourable opportunities for winged creatures to get through it. Certain butterflies, for example, commonly kept at that level, and those that were migrating over long distances used to thread their way in and out amongst the trees at a height of about 30 to 40 feet.

The average height of the true canopy was about 100 feet. From the ground it was not possible to see much of what existed in it. Troops of monkeys were certainly visible enough. Birds could be heard twittering in it. A gun might bring down a mangled bunch of feathers, but it was not easy even to locate their presence through the mass of foliage and the atmosphere of gloom. Occasionally with powerful glasses one might get a glimpse through a canopy window of some lofty tree covered with blossoms, or even perhaps of a humming-bird or a butterfly visiting them for an instant and then flying off. It was just sufficient to give an idea of how rich and unknown must be the tree-top life. It surprised me to see the canopy deciduous in patches. We are so accustomed to associate the falling of leaves with a sharp and distinct change of season. Yet here, in this country of perpetual summer, we often saw a great tree shedding its foliage, then bursting into a cloud of flower, then casting off its blossoms and putting on a fresh coat of leaves. What was known of the animal life of this tree-roof was confined to what a gun could secure from it. Mammals and birds had, of course, been shot from it, but we knew scarcely anything of their intimate lives, and of its small inhabitants we knew nothing whatsoever. Mr. W. C. Allee, in the rain-forest of Panama, had made a spike ladder up a tree to a height of 80 feet. He took a small collection of animals from it, but his main object was to get meteorological records, such as temperature, amount of

evaporation, light intensity, and compare them with those on the forest floor. I am much indebted to him for his valuable advice and for giving me exact details of his climbing method and experiences.

There is another and interesting record of the climbing of a large tropical tree, though certainly not for biological purposes. This was by no less a person than Sir Francis Drake in the isthmus of Panama. "He arrived, on the 11th February, at the top of a very high hill; on the very summit of which grew a tree of great size, from which both the North and South Seas could be seen. Here one of the chief Symerons, taking Drake by the hand, desired him to ascend 'that goodlie and great high tree,' as the manuscript terms it. Having done so by means of steps cut in the trunk, he found that in the midst of the branches they had constructed a convenient arbour, in which twelve men might sit; and from thence he discerned both the north and south Atlantic oceans." This was Drake's first discovery of the great South Sea, and "falling down there upon his knees, he implored the Divine assistance that he might, at some time or other, sail thither and make perfect discovery of the same."

Before leaving England I had consulted several persons with special knowledge of the equatorial regions. Did they think that the tree-roof would be fruitful biologically? What would be the best way of attempting to get into it? All of them believed that it must teem with life. But no one knew much of the nature of that life, and all were rather pessimistic about the possibility of properly investigating it. Many difficulties were suggested, most of which we found to be distinctly exaggerated. The trees were so tall. They were so straight and branchless. Their timber was too hard to take spikes or climbing irons. Their crowns were full of dangerous rotten branches. The climate was too severe for the physical effort. The swarms of ants and other noxious insects would drive a climber down the tree-trunk. Even if we did get into the branches we should not be able to see much owing to the density of the vegetation all round.

Our best plan was to equip ourselves with such gear as would seem most useful for climbing by different methods. If one method failed, another might prove satisfactory. Our chief difficulty would be in making the first connection with a suitable branch in or near the canopy. We thought that rope-shooting machines might help, and brought for the purpose a rocket-firing apparatus and a line-throwing gun. We brought 2000 feet of rope for hauling people up, and suitable pulleys for making block-and-tackles. Also we had a parachute sling of the pattern used in the Royal Air Force. We brought rope ladders in 60-feet lengths which we thought might give access to the canopy and some freedom of movement in the tree-roof. We were advised to take out pointed iron bars, with mauls for driving them into the tree-trunks, with the idea of making spike ladders up some of the large trees. We had wooden 6-feet scaling-ladders which could be fitted to one another; also sprays for shooting poisons at noxious insects, and safety belts of the type that painters use, for wearing when in difficult parts of the trees. But although we seemed to have all the equipment desirable, I pinned my faith on getting help from Indians, who, in the course of their lives in the forest, were accustomed to climb trees.

In this hope of native help we were fortunately not disappointed. Mr. Wood, to whom I had explained our requirements, got us two Indians from the

Pomeroon river who were accustomed to climb Balata trees. Their object is to bleed the trees, from which they extract a species of rubber. Our two balata-bleeders, Jothan and Sebico, turned out of greater value in fixing our first ropes than did our mechanical weapons of propulsion. We fitted them with boots and climbing-irons, and, unless a tree was hopelessly rotten or was surrounded by a tangle of pendent bush-ropes, Jothan or Sebico never failed to climb it. Metaphorically speaking, we got up the trees on the spikes of our balata-bleeders.

The first tree we attempted was a large *Mora Bukia* that stood in the centre of our camp clearing. It was, of course, isolated from the canopy, but this in some ways was a distinct advantage. It gave a clear view of the surrounding ring of canopy which was helpful, particularly for bird observation. The rocket-firing apparatus was first put into action. It sent its missiles with impressive force into and far above the canopy, but the difficulties were in aiming them over a particular branch and in getting the rope to ground again without its being hopelessly entangled overhead. Jothan and Sebico then got on their climbing-irons, and, with circles of rope round both their bodies and the tree-trunk, carried a light rope up to the first fork at a height of 75 feet. Earlier in the day a block-and-tackle had been got in readiness, and one end of this they hauled up and fixed to a suitable branch. We now had a hauling-up apparatus in position. A flat seat was then made with pieces of sapling after the fashion of a bo'sun's chair, and attached to the lower end of the block-and-tackle. Seated on this a man could be hauled up into the tree. The arrangement worked fairly well, but one got scraped by twisting and banging against the tree-trunk. We then replaced the seat with a parachute sling, which only made the twisting and swinging worse. In the end our Indians made us a kind of armchair out of straight sticks and bits of ration boxes, and this was not only efficient but extremely comfortable. One could sit in it for hours observing with ease. A later addition was to fix a downhaul rope to it, by means of which the chair could be kept clear of the tree-trunk or hauled on if the blocks jammed. My original intention was to build platforms in the branches. But the chairs that our men made were so satisfactory that we used them as the permanent observation posts. Indeed, we sometimes accused a person who wanted a quiet nap of going aloft to have it in the armchair. The height of this tree was 120 feet, and we made a permanent observation post on it at 80 feet, which was 5 feet above the first fork. It had a fairly dense oval-shaped crown. From it we could see well into the ring of canopy across a space of 200 to 300 feet, but it provided no view over the forest roof.

Our second place of ascent was chosen because it seemed likely to be a good one for entomological work. It was on a large *Mora Bukia* with a buttressed base, having a girth of 16 feet, a height of 136 feet, a fairly thick many-branched crown, and standing in a rather dense part of the forest. The branches of this tree were buried in the canopy and its top towered several feet above it. We thought that the best way to attempt this tree was by a succession of rope ladders. O. W. Richards and Duffield were the ones who grappled with it, and succeeded in spreading ladders all over its branches and getting themselves to the extreme top of the tree. It was in this part of the forest that we succeeded in getting the bulk of the tree-top collections. The first step was to get a rope ladder from the ground to the first fork at a height of 70 feet. Jothan climbed

the trunk and passed a rope through the fork by which we were able to haul the rope ladder up. The ladder was made fast above and extended out from the tree after the manner of the shrouds of a ship. Guy ropes were fixed to either side in order to check its unpleasant habit of twisting round when one was halfway up. It provided good access to the fork, and at the very first ascent we collected several things of a novel and interesting nature. The trouble about it was that it had constantly to be readjusted, owing to the ladder and the guy ropes shrinking after rain and slackening again as soon as they got dry. The next step was to make a fairly safe climb from the fork out into the surrounding branches. Breast ropes were spread round the fork in order to make a convenient hand-rail. Obstructing branches were then cut away. Then ropes were passed over higher forks and sections of rope ladder hauled up. Other pieces of laddering were placed still higher until, after several days of hard work, this part of the canopy was made fairly accessible up to a height of 135 feet. Richards and Duffield arranged this laddering, which in the hot humid climate was a tedious and sweaty job. From various places in this tree they could see well into the canopy and get glimpses between surrounding trees of the upper surface of the forest roof. Also, taking care, they could clamber about and daily collect the small animals which visited this area of the canopy.

The third place of ascent was selected by the ornithologists. The tree was a Baramalli, one of the tallest in our neighbourhood, which not only took part in the formation of the canopy, but pushed its crown about 40 feet above it. The height of the tree was 150 feet; its girth was 10 feet. Its long straight trunk was cylindrical to the ground, there being no spreading buttresses at the base. Sebico climbed to its first fork at 88 feet and passed a line through. The operation sounds simple enough but it proved to be a whole morning's work. The next day he got himself into the fork and hauled up one end of a block-and-tackle, which he made fast to a branch near the fork at a height of 92 feet. The job took about three hours owing to the difficulty in getting into the fork and to the gear running foul. A chair was then fixed to the lower end of the tackle and access provided to the first fork. Seated at this point, one could get glimpses out over the canopy and could see into it at close quarters. This was sufficient for the moment, but we decided later to raise this post in order to get a full view over the top of the canopy. We did this by stages, and ended by fixing the chair at a height of 120 feet.

The crown of this tree was well branched and rounded. To the north the view was blocked, but southward could be seen some 6 or 8 square miles of unobstructed forest roof. One looked out over a green plain, not altogether level, but raised and lowered into hills and valleys in accordance with the irregularities of the ground and the varying heights of the trees. Unlike a forest in temperate regions, it did not exhibit a uniform tint. There was plenty of colour on the top of the roof. Every shade of green was represented, and many of the youngest leaves were yellow, copper, olive, or red. Several trees showed bright points of flower. Some had large purple lilac-like blossoms; others were pale yellow, pink, and white. How completely a different picture from the flowerless gloom on the forest floor! On the whole the trees were fairly even in height, which gave the roof a smooth undulating appearance, but here and there some special monster sent its head towering above the general level to a height of

some 50 or 60 feet. A glance over the canopy was sufficient to tell one that it harboured a quantity of animal life. Vultures and swifts floated above it; humming-birds, parrots, and other brilliant species frequented its highest branches; dragon-flies swarmed around its summits, and huge morpho butterflies floated over it, visiting its wealth of flowers. Flies continually annoyed the observer at these elevations; grasshoppers and crickets hopped about the branches; ants ran over the stems and foliage; hunting spiders moved over and along the bark, and web-building forms had their snares amidst the leaves.

A fourth entry was made to the canopy up the trunk of an Ulu tree. In this instance a rope ladder was suspended close against the trunk. If actually touching the trunk it would not take one's feet, therefore we kept it from contact with the bark by pieces of bamboo placed crosswise underneath it. This tree was specially chosen because its trunk passed up through a quantity of foliage from which animals could be collected with a net. In this way we could get samples of the life from the intermediate region of the forest.

These tree-climbing arrangements took a good deal of time. Any one accustomed to dealing with ropes will picture the many minor difficulties to be overcome before such gear can be got to run smoothly. Ropes kink, blocks jam, running-gear fouls; then chairs have to be made, tackles to be got ready, obstructing branches and bush-ropes to be cleared, all of which takes so much time that at least three or four days must be given to getting each tree under control. One thing that must always be kept in mind is the possibility of white-ants eating the ropes. The fastenings must be periodically inspected, and petroleum or some other insecticide sprayed over the ropes wherever they touch the tree. Any one wishing to repeat this kind of work would be well advised to use only tarred rope, which insects will probably refuse to eat. It should be remembered that the rotting effect of the climate shortens considerably the life of ropes. The ceaseless shrinking and slackening under frequent rain put a heavy strain on rope ladders. I considered that ours required replacement after being in use for two months. A quantity of vaseline is a necessary part of the equipment. Much is required for greasing blocks, and it can be smeared over ropes where they cross branches in order to keep white ants away. A knowledge of splicing, whipping, and simple knotting is necessary. Indians cannot help in this direction, since they work with the natural bush-ropes.

We were able to put the efficiency of the apparatus to a practical official test. On August 30 the Acting-Governor of the Colony, His Excellency the Hon. C. D. Douglas-Jones, C.M.G., paid a visit to our camp. He took a kindly interest in our various activities and permitted us to haul him up the Baramalli tree to the perch at 120 feet. There he had a fine view over several square miles of the roof of his dominions. A little difficulty occurred at the time of his descent. For a few minutes the blocks jammed; but that is a story which is better untold.

A quantity of biological information was secured by systematic observation from these canopy perches. The ornithologists particularly found the method suitable. Every hour of the day and night is represented in their ornithological record. Using the perches and canopy ladders as a base, it was possible to move about in a limited degree and collect things by scrambling over the branches. But in order to secure more material we devised some large insect-catching

The expedition's camp beside Moraballi creek

Looking south over the tree canopy from Moraballi

Observation chair in use

Insect traps being hauled up 10 feet apart

traps which could be hauled daily into the canopy, where they took their captures automatically. These traps were in the form of large muslin cages with slits through which small animals could walk in, and sloping obstructions that prevented them coming out. Different kinds of baits were used in the traps. Every night with lamps inside they were hauled up into the roof and the catches removed in the morning. They turned out very efficient. We usually had about thirty things nightly from them. Our best catch was 164. They must have added some thousands of specimens to the tree-top collection. By day we baited them with other things, such as pieces of flesh, to attract carrion-feeding insects, and solutions of sugar and the sweet sap from plants to capture the creatures of more delicate tastes. They were very useful for studying the layers of life. We used to hang them in a string at different elevations, often one at 100 feet, a second at 80 feet, a third at 60 feet, and we were constantly surprised at the difference in the catches, which indicated how the animal life of the forest is spread in successive layers. Not only were the species different in the layers, but an Order of insects which was dominant in one layer would be only feebly represented in another. It might be useful for further work in this direction to state the types of capture that these traps can secure. The composition of our largest catch was:

At 40 feet.	Coleoptera (Beetles)	1
	Hemiptera (mainly Leaf-hoppers)	3
	Hymenoptera (Wasps)	10
	Lepidoptera (Moths)	37
	Orthoptera (Crickets)	1
	Arachnida (Spiders)	1
At 80 feet.	Coleoptera (Beetles)	1
	Hemiptera (Leaf-hoppers)	10
	Hymenoptera (Wasps)	5
	Lepidoptera (Moths)	6
	Orthoptera (Crickets)	1
At 100 feet.	Coleoptera (Beetles)	1
	Hemiptera (Leaf-hoppers)	59
	Neuroptera (Termites)	1
	Hymenoptera (Bees, Wasps, Ants)	10
	Lepidoptera (Moths)	13
	Orthoptera (Crickets, Cockroaches, Grasshoppers)	4
	Total catch	164

A party intending to investigate the canopy would do well to provide itself with thirty or forty traps of this pattern constructed of durable material in England. The working of that number of traps would be a whole-time job for one man.

We adopted every device we could think of for capturing these tree-top forms of life. Snap-traps were set in the branches in the hope of getting lizards and small mammals. Vessels containing water were put in suitable places so that dragon-flies and mosquitoes and other water-seeking creatures might find places for laying eggs. This idea came through Duffield finding that mosquitoes bred freely in tree-holes half full of water at a height of 110 feet. I have little doubt that the roof of an equatorial forest is a rich breeding-ground for

Insect traps being hauled up 10 feet apart

Observation chair in use

myriads of mosquitoes, a point which may not be taken into account by those responsible for anti-malarial campaigns in the tropics. From the ground we used a net with a long handle to sweep the vegetation and catch small animals up to a height of 30 feet. From a canopy platform the net could also be used to sweep the branches of the observation tree or those of its nearest neighbours. Our wooden scaling ladders turned out useful, though not for the purpose originally intended. I thought that we might have been able to spread them in the canopy, lengthening and shortening them as conditions required. But we found that for this the rope laddering was more effective. The scaling-ladders were then turned to the examination of the tree-trunks and employed for collecting bark-inhabitants at heights which, without them, it would be difficult to reach. Some creatures were secured by rather odd methods. Duffield, with a 12-bore scatter gun, shot large buprestid beetles while in flight through the canopy; and our Indians with bows and arrows shot birds, lizards, rats, mice, beetles, butterflies, and other insects. But of all the devices for canopy collecting the automatic traps were the most productive, and the best baits with which to set them is carrion by day and lamps by night.

We had brought out with us cylindrical spikes, 14 inches long, 1 inch in diameter, and ending in wedge-shaped points. The object was to build a spike ladder. They were to be driven into the trees with 8-lb. mauls. In practice, however, we found that the trees would not take them. The largest trees would not admit them more than an inch or two. I was able to get them into some of the softer trees, but on the whole they were of little use. Owing to the supposed terrors from noxious insects we were equipped with syringes for squirting poisons. To some slight extent they were useful, but the difficulties from this cause were much exaggerated, and few trees in the forest are likely to prove inaccessible on account of insect pests.

I have already stated that this paper does not enter on biological matters. These will come in due course before the different societies interested in them. But it may not be altogether out of place to mention very briefly the most common and conspicuous denizens of the forest.

Mammals are not particularly noticeable in the forest. They are few compared with the birds and insects. One might easily move about for days without seeing a single individual. The commonest are the canopy-frequenting monkeys, of which five species frequented our area. Daily we heard the roaring of bands of howling-monkeys which seemed to have their own particular territories. A Tapir was shot with a full-grown embryo. Sloths were seen climbing like slow-motion pictures up the bush-ropes or along the tree-roof. Deer, both large and small, were noted swimming the creek or hiding in the bush. The Agouti and the Pigmy Agouti were the mammals we saw most of; they were the commonest food animals brought in by the hunter. Much rarer was the Paca, another of these rodents, which by day used to live in hollow trees and at night come down to feed near the creek. Climbing trees might be seen the Tayra, a kind of foul-smelling giant weasel. An otter was shot swimming and barking in the creek. One day we got a small armadillo. Tree-squirrels were fairly common near our camp. A little mouse-opossum used to swing its nest on pendent bush-ropes over the creek. Mice, rats, and spiny rats used to pillage our cookhouse for scraps of food. Bats were numerous and of many kinds. Our

most striking capture amongst these creatures was a bat with spotlessly white silky fur which used to hang by day under the leaves of the Turu palm, where it blended with their silvery tints. All we saw of the Jaguar, the tiger of the colony, was its footprints near a muddy pool.

It is impossible to do anything but just touch on those birds which make themselves conspicuous through their plumage or voice. Morning and evening over our camp used to fly flocks of green Amazon Parrots and less often of Crimson Macaws. The cu-cu-coe of the Purple-Tinted Pigeon was perhaps the commonest bird-sound in the forest, but more noisy and insistent was the Greenheart Bird, whose succession of penetrating high-pitched whistles reminded me of the well-known brain-fever bird of India. The Toucans, of which there were several kinds, made themselves known by their yelping voices. The Caracara had a noisy screaming cackle. The Wood-Rail gave forth blood-curdling yelps like the screams of a whipped dog. The Banniah uttered a turkey-like gobble during which it performed the strange antics of turning head over heels. Humming-birds were common and delightful creatures. We never tired of watching their poisings and dartings, and at every few hundred yards along the creek might be found their dainty nests. In that zone of life above the canopy vultures and swifts were the most conspicuous inhabitants; on the forest floor were a crowd of dull-coloured species, some of which kept persistent company with ant-columns, others of which, like the Tinamou, Curassow, and Guan, kept our camp supplied with food. A crowd of small birds joined in heterogeneous flocks, tanagers, woodpeckers, woodhewers, and others, some turning over leaves, others probing the bark, others making sallies after insects in the air, but all keeping close company in one common flock. The forest supplied bird-life for years of study, and in addition there were the kingfishers, the herons, the terns, and others that frequented the river and creek. But of all the birds not one made itself friendly to us and became a regular visitor to our camp.

Of reptiles we got 16 species of lizards, 14 of amphibians, and 11 species of snakes. Poisonous snakes were not numerous. All we met with were the Tree-viper and the Fer-de-Lance.

Insects supplied such a plethora of material that I cannot give even the faintest idea of it. I can only say that we saw many remarkable things. Some of the striking examples of mimicry—moths dressed to appear like wasps or leaf-hoppers, spiders shaped to resemble ants, succulent butterflies coloured to look like nauseous ones—never ceased to cause astonishment as example after example turned up. We were interested to meet with those very weird insects with elongated heads that look like miniature alligators, and those caterpillars which, when alarmed, make themselves look like poisonous snakes. Then there were strange assimilation devices, such as mantids that not only looked like leaves but by their movements imitated a leaf in the wind, caterpillars that made bits of leaf into shapes like themselves and then changed their own colours so as to harmonize with the withering bits, spiders that constructed pellets exactly like themselves in order to decoy the enemy from the scene. Spiders, indeed, proved a rich field of study. There were found some quite novel and peculiar kinds, one which hung a trap-door shelter from the centre of its web, another which for concealment rolled itself into a kind of blanket,

another which planted moss on its conical-shaped hiding-place, another which manufactured a hammock and joined forces with an army of ants to defend it, another which cut semicircular pieces from the vegetation not unlike the leaf-cutting ants. In those fascinating problems of insect defence of which Professor Poulton is the recognized authority this patch of forest supplied endless examples. It was, in fact, a Poultonian paradise.

We made some attempts at night observing both on the forest floor and in the tops of the trees. Lights revealed many nocturnal creatures such as scorpions, centipedes, and crickets which hide in holes by day. In the canopy night-ants were seen hunting in packs of a different kind from those that hunt there by day. The nocturnal sounds were insistent and impressive. The loud reverberating roar of the howling monkeys might be heard at any hour of the day or night. Frogs every evening started their music with guttural croaks and metallic chinks, but they usually ceased by 10 p.m., with the exception of one species of bull-frog, which kept up a loud moaning grunt until about 2 a.m. Just at dusk the fireflies illuminated the canopy, sparkling as they twisted in sinuous evolutions, but the display would seldom last more than half an hour, though an occasional sporadic spark might be observed during the first five hours of darkness. The steady whirr and the siren-like whistles of the cicadas were maintained up till about midnight. Few nocturnal birds were evident in the forest, but bats were numerous and kept up their chirpings almost the night long. There was a distinct hush and absence of sound for the two hours that preceded dawn.

No account can be given of the canopy collections until they have been worked out by specialists concerned with the various groups. But it may be said in a general way that the animal life existing in the canopy is quite different from that on the ground and that of intermediate levels. It is a field abounding in animal existence of which we have at present only a fragment of knowledge. In the small area that came under our investigation we have secured some thousands of specimens, but that is a mere drop in the ocean compared with the immensity that remains unexplored. I can think of no biological area of investigation which would better repay concentrated study. There are several kinds of monkeys in British Guiana which habitually live in the canopy and which seldom if ever come to ground. Sloths, squirrels, tayras, some opossums spend much of their time in the tree-roof. I suspect that several kinds of bats search it nightly for insect food. Whole groups of striking birds, such as many parrots, toucans, macaws, cotingas, flycatchers, tanagers, and hummingbirds, live perpetually at this elevation. I was surprised to find only a few lizards and snakes in it. Insects of all kinds abound in the roof. Spiders make their traps in it. Millipedes and scorpions haunt the branches. The many and various flowers that grow on it seem well adapted for insect fertilization. Bees were watched visiting the flowers of the Wallaba, butterflies going to the Cacaralli and Inga, but there will always be no little difficulty in securing exact information on such points.

I will mention the number of specimens that we collected, though our business was more to fill our notebooks than to accumulate quantities of material: 75 mammals, 166 birds, 207 reptiles, about 10,000 insects, about 5000 sets of plants, about 500 miscellaneous. The collection of animals has

been deposited at the British Museum and the plants at the Royal Botanic Gardens, Kew

From the collections made at different levels I have come to picture the life of these forests from a different point of view. Hitherto we have been thinking mainly of the life on the forest floor, and this recent investigation has added to it the life in the forest roof. But that is a very partial picture. Forest life is not only on the floor and in the canopy. Our collections indicate that it is spread through the forest in a series of strata or layers. I consider that we must picture the life of the forest as arranged in successive horizontal strata. There will, of course, be some overlapping in the strata, but in the main we shall find a different life-constitution in the successive layers. I believe that we should examine a tropical forest in the same way as we examine the ocean, not just examine the floor of the forest and then turn our attention to the canopy, but investigate it systematically level upon level and record how the living forms change as we pass from layer to layer. Only by such means can we ever acquire any solid knowledge of the forest life.

How can it be done? I believe the proper way to investigate these forests is to follow some such plan as this. Choose a flat piece of primeval forest. Have a road made through it about 4 miles long and 12 feet broad. Place on that road an extensible ladder, supported below on a wheeled platform and capable of being raised to any level up to a maximum of 100 feet. Fix to the top of that ladder a platform on which an observer can record and collect. I am informed by the best authority that such a stable ladder suitable for the purpose can be readily manufactured. Place the ladder on the prepared road and first raise it to a level of 20 feet. Then push it along the road while the observer on the platform notes, collects, and records everything at that 20-feet level. The epiphytes, mosses, ferns, birds, reptiles, insects, everything found at that level will first be placed on record. This would take about three weeks. Then let the ladder be pushed up to 40 feet and the examination repeated at that level. Then push it to 60 feet, then 80 feet, and finally to 100 feet, which is the level of the canopy. By following an investigation on this plan we should begin to learn something of what at present we know nothing, namely, of how the life of the equatorial forests is distributed in strata or layers.

I cannot conclude this paper without stating how much we owe to our Indians. Our total staff was twelve. Of these two were descendants of East Indian immigrants and ten were aboriginals of the Arawak tribe. These men were splendid fellows, quiet, willing, cheerful, industrious, and genuinely interested in our odd activities. At the same time they were placid and dignified, and, if unjustly rebuked, would quietly disappear. Most of them were born naturalists, keen and accurate in their observation, and there was not a day that we did not consult them repeatedly on matters connected with the forest life. In any activity requiring care and patience, such as skinning birds, preserving plants, sorting, pinning, or labelling insects, they are likely to be better than the average European. For a party in the bush they are indispensable. To us they were hunters, tree-climbers, boatmen, taxidermists, woodcutters, camp-builders, fishermen, trail-makers, and performed a hundred other duties necessarily connected with life in the bush.

We broke our main camp on November 19 and paid a visit to the First Falls

on the Cuyuni river, before sailing for England on November 30. Half our party, owing to University requirements, were unable to stay the full time and had previously sailed on October 5. Our deserted camp presented a picture of desolation. It was a chaos of straight sticks and forks, the skeleton framework of our several shelters. Broken packing-cases, discarded ladders, old tins, and piles of rope lay scattered about the ground. In the midst of it all were the stumps of the felled trees, which by now had thrown out again quantities of fresh vegetation. Their rate of growth had been remarkable, but what surprised me more was to see them branching freely after the manner of our English trees. For these trees under ordinary forest conditions never give out branches till they get near the canopy at a height of about 70 feet. Yet, when hewed down in the middle of a camp clearing, they gave out branches freely like our temperate trees, and not only from the cut stumps, but even from the buttresses which are modified roots. But no doubt this struggle on the part of the tree-stumps, so severe that they change their whole mode of growth, will be only a transient and failing effort. In a few years the hundreds of saplings will press in on them, and they will fail before the more vigorous growth.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: Major Hingston, who is to lecture to us to-night, was the leader of the Oxford Expedition to British Guiana. That expedition was mainly biological, but our Society was able to help with money and instruments so that there might be a surveyor; and although the work done did not take place exactly where we expected it would, Mr. Slater, the surveyor, was able to do some very excellent work.

Major Hingston has been for a long time a Fellow of this Society. He first came to our notice when he served on the Anglo-Russian Pamir Expedition which joined up the triangulations of those two countries. Although I ought to know, I am personally a little uncertain where the Russian triangulation went, but I understand it did not thoroughly join up their European work with the Asiatic, so that India is tied to the Central Asian work, but not with Europe. Then Major Hingston was the medical officer of the Mount Everest Expedition of 1924, and, you will remember, in that capacity he was instrumental in bringing Colonel Norton down from the North Col when Colonel Norton was smitten with snow-blindness. Major Hingston was last year with the Oxford Expedition to Greenland, so he has a very varied experience of the tropics, of the polar regions and, I might almost say, of the upper air, because this time he is going to lecture to us largely about the tree-tops of British Guiana.

Major Hingston then read the paper printed above, and a discussion followed.

The PRESIDENT: We are fortunate in having with us this evening Sir Edward Denham, who has recently been appointed to the governorship of British Guiana. Perhaps he will say a few words about the territory which he has not yet seen.

Sir EDWARD DENHAM: I find my introduction to you puts me in a difficult position as, unfortunately, I have not yet seen the country I am going out to govern; but I should like to thank the lecturer for giving me and, I hope, those who will follow in his footsteps and in mine and visit British Guiana later, a very happy Prelude to Adventure, for such I think this lecture has been. The excellent photographs he has shown tell us of the natural beauties of the country which he visited and indicate that those beauties do not reside merely in the tree-tops but

are to be found in the reaches of the rivers, in the wide expanses of savannah which lie behind those rivers, and in the interior as well as on the coast of the colony. I think sometimes members of geographical societies must wonder what realms are left to conquer, what unknown places there are still in the world which can be visited by explorers. As the lecturer has well said, it is good for us to know that there are still some quiet untouched spots left, places which are just as unexplored, just as remote in their way as Arctic regions. In British Guiana the Fabres and the Beebees and other lovers of the insect world can study that world in the fastnesses and in the wealth which it there enjoys.

It is quite true that a great many people do not appear to know where British Guiana is. A learned society, the name of which I will certainly not divulge, of which I have the honour to be an honorary member, sent me recently a list of its members, and I noted that my address was given as Government House, British Guiana, West Africa.

British Guiana is a country the size of England, Scotland and Wales; it is a country which has been very little developed hitherto; a country on which a great deal has been written and which many must have visited and explored in different parts, but with which the name of Raleigh is still connected as perhaps its greatest explorer. There are still mountains to be climbed, rivers to be navigated, forests to be opened up, mines to be worked. Undoubtedly it has scope not merely for the discoverer, not merely for those who will interest us in the animal wealth and insect wealth, but also opportunity for those who are interested in the industrial, commercial, and mineral wealth of our colonies.

I am not going to make a speech about British Guiana, for I know very little about it as yet, though I hope to know a great deal soon. All I can say is, speaking on behalf of those interested in the country—and all must be interested in the possessions of the British Empire—that there are openings there and possibilities for those who wish to come and help us to develop that part of the Empire. I think at the present day there is no part of the Empire which more demands sympathy than the West Indies and the countries connected with them. They demand it on many grounds. Sometimes in our natural pride in them we are a little apt not to give the same emphasis to the responsibility that we bear to them. The country of which we have heard to-night is one for which we have a great responsibility, and I hope that responsibility will be given effect to by showing practical sympathy with the country by assisting in its development and by taking an interest in it, for the more interest taken in our possessions the better for them and for us.

I am sure for all present I may thank the lecturer. I should like to say on behalf of the people of British Guiana whom I shall have the honour of representing, that we owe Major Hingston and the Oxford Expedition a debt of gratitude for what they have done in exploring the fastnesses of the tree-tops of British Guiana. I desire to extend a welcome to all expeditions which will help to make us better acquainted.

Mr. T. A. W. Davis (Forest Department, British Guiana): It was my privilege to be detailed to accompany the Oxford University Expedition, and I think the chief reason was that the Government considered that there was something of real value in the expedition; that apart from the purely scientific side it would eventually come to be of some value from the economic point of view and, as my chief said, he thought he would like to have somebody with the expedition to pick their brains. When the expedition was decided on I happened to be the only person available, so I had the good fortune to be sent with it.

I think Major Hingston's description of the tropical forest is extraordinarily clear. One reads descriptions by well-known writers, I suppose very good

descriptions, but they never seem to convey anything. From Major Hingston's description we got some idea of the atmosphere of the forest. There are one or two points on which he did not particularly touch which might be of interest to you. He said when we went up the creek we only had to cut away a few branches. That was true, but that creek is actually being worked for timber and has been kept clear—very roughly, I admit. Those who work in the timber grants do not do a stroke of work which they need not. Many of the turnings were very dangerous for timber punts. However, that did not matter. You see, if there are two people working on a creek and one fellow clears it the other gets the advantage, so neither will clear it! One photograph in particular showed us a path used for the extraction of timber. That creek produces one of the well-known timbers of the world which, incidentally, I do not think Major Hingston mentioned, namely, the greenheart, which is one of the commonest trees in the creek. At present it is the only tree in British Guiana worked economically on any scale, at any rate for export. One of the reasons why the Forest Department in British Guiana was so interested in this biological expedition was that we have very little botanical knowledge of our forests and very few of our timbers are at present worked economically. We are often handicapped by not knowing the names of the trees. Some may have been collected and named by botanists, but we do not connect up our trees with those names. Naturally, until that has been properly done it will continue to be very difficult to create a market in something for which there is not a name. That side of the work was of interest.

I should like to enlarge upon what Major Hingston said with regard to the Indians. I was extremely pleased at the way they worked in with every member of the expedition from the first. The Indians are extraordinarily shy and retiring, and until they know one pretty well, although they will not refuse to do anything, they are too shy to understand what is wanted when asked to do something. That did not happen on this expedition. Most of the Indians had been employed by the Forest Department; some of them had only perhaps been on one trip of three months, but they got on extraordinarily well with every member of the expedition. I will conclude by saying how grateful I am both to the Government of British Guiana for sending me and to Major Hingston for all his kindness to me on the expedition.

Mr. L. SLATER: As surveyor attached to the Oxford University Expedition to British Guiana I have been asked to say a few words with regard to my work. In the country so excellently described by Major Hingston the only practical way of penetrating into the interior is to make use of the rivers, and every river in the colony has a series of rapids somewhere along its length. Our base camp was to be on Moraballi creek, which is a tributary on the right bank of the Essequibo river. It was found that the cost of transporting us above the falls on this river, or others, was prohibitive; it meant employing specially skilled and highly paid boatmen. Therefore I was confined for my surveying operations to the portion of the Essequibo river below the first fall.

On consultation with the officials, in the Surveying and Forest Departments in particular, I was assured that the most useful work I could do for the colony would be to triangulate and map the Essequibo from Bartica upwards as far as the first falls. This was, in fact, a continuation of the triangulation which had already been carried out by Captain Gibson of the Hydrographic Service. He had triangulated and surveyed the river from the mouth as far as Bartica, and starting from his last two stations I continued the work farther upstream. Major Hingston gave an excellent description of the forest wall closing in on the river, and he has not exaggerated in the least. It really is like a wall, and as I was alone with only four Indians as helpers it was impossible to do much in the way of clearing into the

forest. The Indians were extremely good at clearing, but there was not sufficient time or labour available, so many of my stations for the surveying had to be built out on mud banks, which necessitated special devices for overcoming the unfirm character of the foundations. Building platforms, driving long piles through the mud to firmer foundations underneath, was one of the methods adopted. Another big difficulty was the fact that although the river was 2 miles wide on the average, in places there were big, very densely forested islands, right in the middle of the river, considerably reducing the effective width for triangulation.

I carried out the triangulation from Bartica up the river for nearly 20 miles, as near to the first fall as possible, paying special attention in detail mapping to the right bank, which had only been mapped by the roughest methods. My main task, in fact, was the accurate mapping of this bank and the islands, for even the best existing maps were very inaccurate in this respect. In addition, there were numerous tributary creeks on the right bank, of which Moraballi was one, which were absolutely unmapped. These I traversed in canoes with Indians, and not the least of the difficulties encountered there was that suggested by Mr. Davis, the fact that creeks, unless kept clear, are very difficult to negotiate.

In conclusion I ought to thank Major Hingston for his excellent description; he has really left very little for any one else to say in describing the country. I suggest that there is great scope in the colony for accurate surveying, especially for a kind of inventive surveying of a distinctly unusual character.

Dr. T. F. CHIPP, Assistant Director, Royal Botanic Gardens, Kew: The lecture to which we have just listened is a useful and valuable record of field technique. Major Hingston mentioned that when he made preliminary inquiries as to how to climb the big trees of the tropical forest, he was unable to obtain the information he required. It is a fact that those of us who are accustomed to do these things forget them, and a record of first impressions such as we now have will be a valuable guide to young scientists on their first adventure into the big tropical forests.

Mr. Sandwith was sent out from Kew and we were enabled to arrange this thanks to the financial support which the Empire Marketing Board gives us for purposes of this nature. It may not be evident at first sight as to why the Empire Marketing Board should interest itself in such a venture, and what is the connection between such scientific investigation and the marketing of Empire produce. May I illustrate this by a recent example? Last week a Colonial officer of many years' experience came into my office to discuss forestry and cacao cultivation. It is well known that cacao must be grown under the influence of the forest where a continental climate obtains. Formerly there was much forest and little cacao. Now in places there is beginning to be found much cacao and little forest. The question is, how much forest is necessary? In order to answer we must know in terms of inches of rainfall, degrees of heat, percentages of humidity and other factors what the value of this forest is. We know little about it at present, and yet the Empire produces the bulk of the world's cacao. This incident amply demonstrates the manner in which production is governed by, and is dependent on, scientific investigation of the natural vegetation.

At the moment expeditions such as the one led by Major Hingston are almost the only means we have of gradually accumulating the data which are so much required. Were it possible to convert these isolated expeditions into a "standing camp" under a permanent camp commandant, we should be enabled to continue investigations over the whole year and so observe the periodicity of the vegetation, and also be able to provide practical experience in the field for the scientific worker before he is harnessed to any particular problem.

In the meantime, however, we must welcome contributions to science such as

these expeditions are able to make, and realize that the information obtained will have important bearing on applied botany, agriculture and forestry.

The PRESIDENT: I think you will agree that the lecturer has shown that there are no hard-and-fast limits to exploration. As we have heard, surveyors are capable of going up into the trees, if necessary, and if there should be such a thing as a journey to the interior of the Earth, which was talked about in my young days by Jules Verne, we can go there too. We do not limit ourselves to two dimensions: we explore in three. We are very glad to have had an example of exploration in three dimensions given to us so admirably by Major Hingston. I am perfectly sure that to most of us it is a revelation of what does really exist in those great forests. I suppose that one of these days they will disappear and everything there will look like Clapham Junction. Anyway, we hope during our lifetime that they will persist. The expedition has done a fine piece of work. Mr. Slater has done good surveying, though it was not what we expected, because we thought he would be able to go in another direction. I have not yet seen the results of the work, but I can fully bear out what he says as to the difficulty of surveying in those wide rivers and creeks, because I have tried it myself. It is really very troublesome.

I might add that there was one very remarkable feature about the expedition. We gave them some money for their work, and they returned a portion! In thanking Major Hingston for his admirable lecture we wish to congratulate not only him and his companions on their work, but we should also like to express our appreciation of the work of the Indians who helped them.

THREE JOURNEYS IN THE TIEN SHAN, 1928–1929: *A paper read at the Evening Meeting of the Society on 19 May 1930, by*

LIEUT.-COL. REGINALD C. F. SCHOMBERG, D.S.O.

THE journeys described in this paper lie wholly in the Tien Shan. The first began with the ascent of the Kash valley from Ili or Kuldja, then crossed the main northern range to the west of the Manass mountains, and ended by reaching the main Manass–Shihho road. This took place in 1928. In 1929 a start was again made from Ili. The Kunges valley, which lies south of and parallel to the Kash, was followed to its source, and the route, continuing due east, led over the Könsön Dawan, along the head of the Little Yulduz, down the Algoi Sai to Toqsun. A little later in the same year the Tien Shan was crossed from north to south by a difficult but locally well-known track over the Tengri Dawan, through both the Little and Great Yulduz, and over the group of passes in the main Southern Tien Shan, skirting the small lake Qara Köl, and over the Qirghiz At Dawan to Kucha.

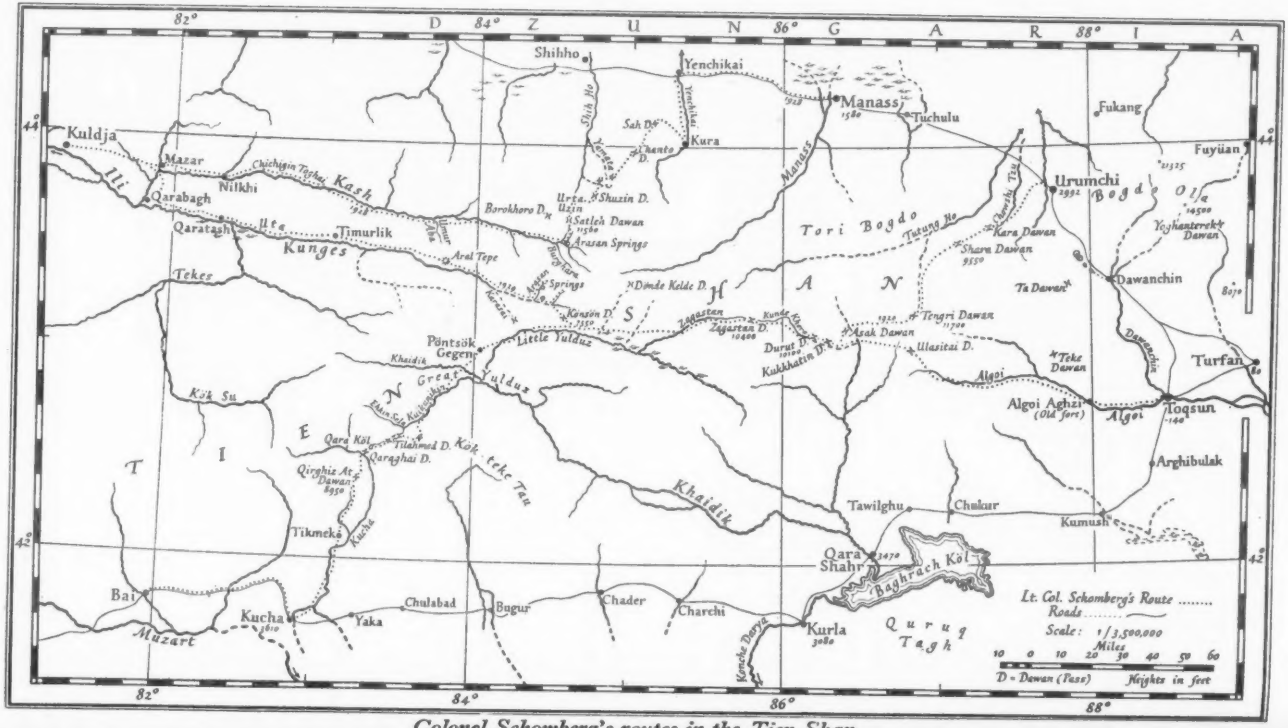
The object of the journeys up both the Kash and Kunges was to find a route that led down directly on to Manass. The local people insisted that there was none, but unfortunately in Central Asia, and perhaps even elsewhere, such assertions are not always strictly true. Our failure to find such a track was not wholly our fault, as will appear.

No one who travels in Asia away from rail or metalled roads should expect comfort, and harrowing descriptions of the inevitable disagreeableness and hardship of travel in Central Asia are out of place and boring. For the benefit of future travellers, however, it is well to point out that the weather in the Tien Shan is so fickle and so impossible to judge, that the climate of the British Isles is monotonously regular in comparison. Professor Merzbacher, in his book on the Central Tien Shan, published by this Society, complains bitterly of the vagaries of the climate—and with reason.

We left Kuldja on 31 July 1928 and went up the right side of the broad cultivated Ili valley. Just below Mazar, a village with a large and frequented shrine built in the Tungan style, the Kash river flows through a gorge into the Kunges, and the united stream is called the Ili river. Continuing up the right bank of the Kash river, the country became down-like in appearance, though deep and unsuspected gorges made travel away from the river quite impossible. These narrow gorges, really deep canyons with foaming impassable streams, are a feature of both the southern but particularly the northern, slopes of the Tien Shan, and more pronounced perhaps in the northern than in the southern range.

It is unfortunate that there is no means of distinguishing the two arms of the Tien Shan, except by a vague and unsatisfactory periphrasis. The mountain people, though nomads, are too local in their outlook to invent a name or even to realize the need of one.

The debris brought down by the streams has formed subsidiary hills between the river and the mountains on the north, which makes the right of the Kash valley very broken and tedious to travel through. This fact and the difficulty of crossing the swollen streams flowing from the north, compelled the route to cross the Kash by a ferry-boat very like a coffin. The *modus operandi* was simple.



Colonel Schomberg's routes in the Tien Shan

The boat or box, loaded to its utmost and with two horses attached, was thrust into the boiling, tearing flood, and tore down the river at a prodigious rate, until it was near the opposite bank, when the horses were lashed, the craft reached the bank, and the frightened passengers scrambled out.

Just below the ferry, and above Nilkhi, the last village, was the summer encampment of the Zungur lamas, at Chichigin Toghai (willow plain), a striking collection of sixty-four large white felt tents on a grassy plain by the willow-fringed river. The sacred tabernacle with a blue and yellow covering, and distinguished further by a small gold spire, was an impressive feature in the centre of the circle. The lamas were extremely courteous, and appeared prosperous. Their winter quarters, with monastic buildings, temple, and a large chorten, were 8 miles above Nilkhi.

The country on the left of the Kash was even more down-like than that opposite, and it rolled away, fold upon fold, until it culminated in the grassy watershed between the Kunges and the Kash. The track now rose high above the river, and to the north the serrated peaks of the Tien Shan, a stark wall of fretted stone, stood out naked against the blue sky, for there was little snow left on the rocky summits. At the end of the valley the snows and glaciers of the Manass group gleamed.

The Kash valley became more alpine in character, and the right side of the valley was particularly broken by deep fissures; and its difficult nature was evident from the fewness of the auls, in spite of the abundant grass. On the left side of the valley, however, these comfortable beehive tents were standing everywhere. Dense spruce forests covered the hillsides, and park-like prairies stretched along the river. The views up the dark forest-clad side glens were tantalizing, inviting exploration which leisure did not permit.

The Kalmuk area was now left. A little farther up on reaching Umur Aba we found several small camps of Chinese who were collecting the annual taxes from the Kasai Qazaqs who swarmed everywhere. The taxes are paid in kind, and are levied at the rate of 2 per cent. of all animals. We overtook many dejected but loyal owners, driving back beasts which the Chinese, very wisely, had refused to take. No one but a Qazaq would have expected it to be otherwise.

The chief of the Kasai was here, a stalwart, active man of fifty-three, who but for his clothes might have been a British farmer. A curious pest of flying stinging ants had been a nuisance near Umur Aba, and pursued us for miles over the plain.

The weather now became very bad, with drenching rain and driving wind, and hailstones as large as cherries, which made the dogs howl mournfully and flee into the long grass for shelter. Above Umur Aba the scenery became delightful, the forests were thicker and deeper, the valley sides more regular, and the smaller nalas more frequent. The auls, too, were very numerous, often pitched high up close to the snow-line, on some bleak exposed slope, where the fine pasture was ample compensation for distance and discomfort. The river gradually became less formidable, and we re-crossed to the right bank quite easily just below the junction with the Burghara, a valley and stream almost equal to the Kash, coming in from the south-east. The forest here ended, the scenery grew rugged and wild, and the last nomads were left behind. We should have felt happier with a guide or a map, but there was neither. The

Qazaqs all swore that we had reached a cul-de-sac, and advised us to go back and retrace our steps down the valley. All forms of persuasion were used by us to glean some information about the route, but we could discover nothing except that we should have to turn back and retrace our steps.

Continuing up the valley we came in 6 miles to the warm springs of Arasan. The neighbouring Kunges has a similarly named valley also provided with a hot spring. Not knowing what to do, we turned left up the Arasan Ridge, but were disappointed to find that the two heads of the valley were blocked by immense glaciers, splendid to look at, but not adapted to our purpose.

After we had camped on a wretched bit of grass as far up the valley as we could go, we saw two Qazaq marmot hunters scrambling down the valley side on their ponies. Waving our largest teapot we persuaded them to come near us, and entertained them with tea and talk. They said, pointing vaguely towards a heap of boulders, that there was said to be a pass in that direction, so the next day I went over with one of my men. The pass proved to be excellent, as passes go in the Tien Shan. The ascent from the Kash side was steep and stony, but on the northern side the descent was over soft shale at a slope of 45°, very awkward for the first 100 yards immediately below the pass, but otherwise not difficult. The track wound down under huge gendarmes to an open valley. This pass is the Satleh Dawan, and seems to be a little to the east of the Borokhoro, which means "grey hollow" in Mongol. I am however prepared to admit that the Satleh may be identical with the Borokhoro, in which case the latter seems to be marked too much to the west in existing maps. On the other hand, Merzbacher, in his map, seems to put the Borokhoro more to the east, in a network of difficult peaks and glaciers. The real explanation is that the maps of the whole area of the Tien Shan are quite inaccurate, and the only remedy is a completely new survey. At present every traveller, and I am no exception, bases his maps and sketches on the work of the original cartographer, so the original error increases. The height of the pass was 11,560 feet. Crossing it on 15 August 1928 we found ourselves in the Urta Uzin, a valley with two long arms running respectively east and west, and surrounded by glaciers. The grass and vegetation were abundant, but the valley was entirely deserted, and the only sign of man was a deserted shikari's hut. Descending the valley, we passed through a dense growth of willow and extensive groves of well-grown poplar. We were now growing a little anxious, as we had not very much food and did not know where we were. A short march of 10 miles down the valley ended in a magnificent canyon, with lofty precipitous walls of stone soaring up from a rushing unfordable stream. Turning east, we ascended the Shuzin stream and camped by the Aqsai torrent, quite impassable at midday, as the stream flowed from a fine cirque of peaks to the south, and the melting snow came down in flood by that time.

We had that day passed a number of deserted sheep-folds and much fine pasture, and the desolation of the valley called for explanation. We subsequently discovered that the water in the Urta Uzin stream had risen so much of late years that the valley had been abandoned. Near the Aqsai torrent we found two Qazaq youths who gave us some directions, and after a day's halt to enable the baggage to get halfway up the pass, we crossed the right of the Shuzin valley, and then over a pass as steep as the side of a house. At the top we skirted

the head of a small valley over bad shale close beneath a glacier, and descended easily into another valley with a very large glacier and moraine. As we had little idea where we were we should have halted, and indeed wanted to do so, but there was no grass, and no dung for fuel, not even enough to boil a kettle. Here we went wrong, as we crossed the valley, toiled up an interminable shale ascent, passed the head of two valleys which lay far below, and in pouring rain reached the cul-de-sac of Kara Mören. The sight of sheep cheered us up as we hoped it meant a comfortable aul, but to our disgust the hardy herdsmen had no better shelter than an overhanging rock, and this disappointment made our tempers viler than ever. We spent two miserable days here in the snow, retraced our steps to the previous valley, and camped at the foot of the Jingsikuzhan Dawan, where we lost time by having to reconnoitre the pass, which proved to be a long stiff climb to 12,435 feet.

Crossing on August 24 we were rewarded with fine views, thanks to a break in the weather, and descended to the well-known yailaq or pasture ground of Yamata, an extensive grassy valley much frequented earlier in the season, but now nearly deserted, as the grass was all eaten away and the short summer of the Tien Shan was over. Crossing the Yamata Bash Dawan—an easy pass—we then struggled up to the Narin Köl Dawan. The first 400 yards of the ascent was very steep, over hard earth sprinkled with stones. In fact it was stony, with layers of shale, in parts all the way to the top of the pass. The cold was intense, with a bitter wind blowing, and there was little view as the clouds hid the peaks. On the north side the path crossed a glacier for 900 yards, then went over a moraine and down to a clump of willows. Here the valley again became impossible, and it was remarkable how consistently all these Tien Shan valleys narrowed into a canyon-like gorge.

Journeys in the Tien Shan are thus always sideways, down a valley as far as possible, then over its side into another one, which is followed in the same fashion till it too becomes closed. It is a tedious business—difficult for man and beast, but this crab-like form of progress is the only possible.

The track out of the Narin Köl was very steep and greatly tried the worn-out ponies, and the top of the pass, the Chanto Dawan, was reached in 2½ miles. The view back was fine, but rather marred by the weather, and the autumn tints were well advanced, showing how near winter was. Leaving the pass the track led down the Chantoleh valley for 5 miles, then crossed the Sah Dawan, with a view of the river Shih Ho, and the plains, and followed down the Sah valley, which was very narrow and gorge-like, with dense forest and undergrowth and striking cliff scenery. Then suddenly the valley ceased, and, as if by the touch of a magic wand, the trees, stream, grass—the verdure and freshness of the mountains—all vanished, and the hot plains of Dzungaria lay before us. The ponies required a rest, and we all needed food, so we camped for several days near the Yenchikai river, and straightway the servants took the opportunity to go sick. Manass was reached on September 9, and the distance from Kuldja proved to be 350 miles.

Having already visited the Kash valley I was anxious to see the parallel valley, the Kunges, and hoped that we might be more fortunate in finding a way over into the Manass district than we had been. We started from Kuldja on 23 April 1929, St. George's Day. The weather during the previous journey

had been consistently bad, and as July, August, and September seemed wet months, it was hoped that April, May and June would be dry. The hope was a vain one, for the weather proved villainous. For the first few miles we followed our track of the previous year, but before Mazar we crossed the Kash river by a bridge just below the red sandstone gorge which almost blocks the valley mouth. The river, even so early as this, was a turbulent unfordable stream. We continued up the valley with the Kunges near us on the right, and left the last cultivation at Qarabagh, and we were sorry to do so, as, though the Turki is a tiresome creature in many ways, he can usually provide good victuals. His tastes, too, were our tastes, and the future was of doubtful alimentary promise.

The difference between the lower Kash and the lower Kunges was very marked. The Kunges was a wide level valley, with abundant pasture, watered by a winding sluggish river, and bounded by rather low and commonplace hills. There were often many poplars (*Populus alba*) and some brushwood near the river, but elsewhere the valley and hillsides were treeless, and the fuel difficulty in consequence was a nuisance in places. But the touch of spring coloured everything. A small blue iris, a yellow poppy, and berberis were abundant, the primulas were coming out, and the banks of the river flashed emerald under the bursting shoots of the new reeds.

At Qaratash the Tekes river, a fine stream, comes in on the left from the south-west. It was remarkable that the Tekes was lined with trees, usually willow and poplar, whereas the Kunges above the junction was devoid of any. The explanation probably is that the Tekes is the faster, remains in its bed, and thus allows the reeds and plants to grow. The Kunges is sluggish, often changing its channel, and giving vegetation no opportunity to reach maturity.

The Kasai Qazaqs were the owners of most of the Kunges valley, and their flocks and herds and tents covered the plains. The Kasai is less attractive than he believes himself to be. To begin with, he is a thief, preferably a horse thief, but ready to steal anything from a cooking-pot to a cigarette. He is a born bully and a bluffer, and not particularly hospitable. But we knew our men, and got on admirably with them, and never allowed ourselves to be bullied by them. We always, however, kept a sharp eye on our property, and passed through the Qazaq country without losing anything.

In the lower valley lay the great plain of Uta, covered when we crossed it with tents and animals, as the grass was plentiful, though even in April water was already scarce. North of Uta the scenery improved as the main range of the Southern Tien Shan, previously separated from the valley by the hills between the Tekes and the Kunges, came in on the left with its forest-clad slopes. The north or right side of the valley remained bare, and it was only some miles above Timurlik (where there are old iron workings) that a little brushwood and spruce were met. The Kunges was here 50 yards wide, a deep, muddy, unfordable stream, with brakes of reed and high grass and treacherous sides.

One difference between the Kunges and Kash valleys lay in the absence of lateral affluents in the former, whereas in the Kash these were very frequent; indeed, in the lower Kunges the only tributary was the Tekes river. The low isolated mound of Aral Tepe in the centre of the valley was a continuous landmark for two or three days before reaching it; and it was noteworthy as being the point where the Kunges valley definitely assumed a mountainous character.

We spent a couple of days pleasantly enough near the village of Aral Tepe, a rather dreary collection of ramshackle huts, for the nomad in a house makes a poor job of it. The scenery however was delightful. The river ran through forests of wild apple-trees in blossom, and dense thickets all burgeoning with the first touch of spring. On the southern hills the fresh tracks of the first travellers of the year over the Chang Ma and Narat passes were visible in the crisp snow, and all around us were spruce forests hanging from the steep mountain sides. The chiefs of the Kunges Kasai Qazaqs, Urus Bai and Turus Bai, father and son, fat, prosperous, jolly souls, entertained us. They ran the most successful horse-stealing association in Western Sinkiang, were arrant liars, bluffers, and thieves, and were hospitable, helpful, delightful humbugs, the typical Central Asian mass of contradictions.

We noticed here many abandoned farms, and were told that they belonged to Sarts who had come up here, and finally abandoned the trying life of the farmer for the free life of the veld. Indeed, a number of settlers had turned nomad, and so long as Central Asia remains what it is there is little likelihood for the Qazaqs or Torguts taking to husbandry, for what inducement can they have?

On leaving Aral Tepe we passed, 9 miles up, another long low isolated hill, Baiying Yurek, and we camped at Uliasutai, where the valley bifurcated, by a river lined with poplar, birch and apple-trees, berberis, briar and juniper, the light greens of their partly opened buds contrasting with the background of sombre conifers. The names now became Mongol—Uliasutai means "poplar" —and a few miles on the Kalmuk grazing-grounds were entered. It is worth remarking that the distribution of the pastures is incomprehensible to a traveller. The Chinese may have some subtle scheme, they may even be assuring compensation to dispossessed herdsmen, but the plan of dividing the same valleys amongst hostile tribes leads to endless friction and bitter feeling. One valley for one tribe should be the rule.

On leaving Uliasutai the river flowed picturesquely through a very narrow thickly wooded valley, where we saw many wild pig. The track was awkward, rising high over spurs, and then dropping steeply to river-level again. A little farther up the valley forked, and the fine Karasai streams came into the Kunges, which above this junction was now known as the Arasan—the same name as the upper waters of the Kash. The scenery continued fine, but the track was tiresome, being often in the river over boulders. This narrow gorge of the main valley was about 25 miles in length, when the character of the country changed unexpectedly. At the end of the defile we emerged on to an open rolling country, with high mountains on the south and grassy uplands on the north, while beyond the latter the country became very wild and rugged. Here we met the Kalmuks or Torgut Mongols, and we were not very pleased to see them; with all their virtues their ways were hardly ours.

At this point it was impossible to determine which was the main stream, but it seems reasonable to suppose it was the Yeldi Usun, which continued in an easterly direction to the foot of the pass. The stream that flowed from the north, however, was called the Arasan. Going up this lovely valley, passing first of all the grassy downs and clumps of conifers in the sheltered spots, we reached the hot springs, 15 miles farther, where had been built rough baths with painted figures of Buddha above them. The water was very hot, and just

bearable to the hand. Unfortunately the journey up had proved too much for the thermometer, and the temperature was not read. The altitude of these hot springs, of which there were certainly twelve with a copious flow, was 7965 feet. The springs were surrounded with a regular midden of mutton bones, the remains of the patients' meals, and bits of felt. The water was clear and almost tasteless, with only a trace of sulphur. There were plenty of tadpoles, and also (it was said) snakes, so that it was dangerous to graze animals here. Pushing up the valley, much impeded by the dense growth of juniper, we came to a moraine of recent date (the trees were still standing amongst the stones), from a small glacier dominated by a magnificent pinnacle of rock. After passing a few stunted conifers the valley turned south-east and ended 2½ miles farther on in a smooth saddle of snow, that compared poorly with the magnificent rock peaks on either side.

After being snowed up for two days we again reached the junction of the Yeldi Usun and Arasan. Crossing the high downs between the two, we passed a number of small tarns. One of the prettiest was the Noghan Nor, which the Kalmuks said was very unhealthy, as any one staying by it got covered with a nasty rash, or pains in the limbs. It sounded like malaria. This lake consisted actually of two small lakes, and mallard, sheldrake, teal and geese floated in them, while pigeons fluttered in the trees. The local people regarded the Arasan as the main stream, but the wider one was the Yeldi Usun, or Tsarno Usun, though there was less water in it than in the former. On the other hand, later in the year it would carry a larger stream, as it drained a greater area.

After being delayed by bad weather at Ulan Kura (the red lamasery), we ascended the Yeldi Usun valley to the Könsön Dawan on our right; we continued up the valley, now called the Tsagan Usun (White Water), but found it less attractive than the Arasan, as it proved to be much more rocky, and consequently held little grass or forest. The track, too, was difficult, and the climb was considerable. Fifteen miles from its junction with the Yeldi Usun, a large moraine at 9340 feet above the level almost blocked the valley, and it was observed that a small lake was beginning to form here in the red sandstone detritus. Beyond was yet another moraine, and the valley ended in a wide circle of rocky peaks, with much shale and moraine in the valley bed. There was said to be a difficult track at the head of the valley, but no trace of it could be found. It was, however, probably too early in the year, as it was not open till July. The weather was severe for mid-May, and we were again snowed up, as the snow fell for twenty-four hours with a bitter wind.

Descending, we returned down the Tsagan Usun, and camped at the foot of the Könsön Dawan at Koyur Bulak (Two Springs), height 6380 feet. From here we crossed the easy Könsön Dawan, 7550 feet, which was one of several ways over the low ridge separating the Kunges from the Little Yulduz. The contrast between the two sides of the pass was great. On the side of the Kunges was a richly wooded valley with fine forests of spruce, whereas the Yulduz was a vista of low paltry hills, with much stone and not a vestige of a tree or bush. This insignificant pass is on the watershed between the Kunges and the Yulduz drainage system, and is an important geographical feature in Central Sinkiang, separating as it does the two principal catchment areas excepting the Pamirs.

Leaving the Little Yulduz and crossing pass after pass we finally arrived at

Looking up the Arasan, tributary of the Kash

Satleh Dawan from north side

Hot springs of Arasan, Kunges: looking up the valley

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Toqsun, in the Turfan oasis. The weather was not propitious. Day by day for fourteen days it snowed. There was no grass and no fuel, except wet horse-dung; and as we had no maps we proceeded rather by the light of nature than by any other means. We became heartily sick of the Yulduz, and still more of the filthy Kalmuks, but we had not yet plumbed our hatred for either.

On the way to Toqsun, whilst crossing the 28 miles of sai (desert of stone or gravel) between the Algoi valley and the oasis, we were overtaken by the worst storm for a century. It destroyed almost every camel and most of the sheep within a large radius, filled up the Kariz (underground water-course) at the most critical time of the irrigating season, blasted the young corn, blew down walls, killed old women and children, and devastated the countryside. We passed the night huddled together in the desert, and lost all our light articles as well as five horses. I resolved never again to pooh-pooh the Central Asian buran.

These journeys up the Kash and Kunges had shown that there is no means of reaching the Manass by any satisfactory route through the mountains. The route over the numerous passes from the Kash is possible but difficult, and circuitous; from the Kunges there is practically none; and in no case is there a practical track that leads directly to Manass.

A little east of the head of Bagha or Little Yulduz it was possible to identify the Dönde Kelde Dawan, which figures so prominently in many maps. It is the centre of three adjacent valleys coming in from the north: the Hörte Kelde, the Dönde Kelde, the Ömnö Kelde, taken from west to east, and meaning the Hind Foot, the Middle Foot, and the Front Foot. These are all very difficult passes, and seldom used, as they are only open for a few weeks in the year, during the brief period between the end of the summer, when the snows have melted, and the beginning of winter. The season prevented us from trying them, and they can be dismissed as being of no real value as a route.

The third journey in the Tien Shan was from Urumchi over the Tengri Dawan through the Great Yulduz to Kucha. The route is regularly used, but little known except locally, and an account may be interesting. Whatever virtues Urumchi, the capital of Sinkiang, may possess, they are hidden from sight, and we were not sorry to leave on 4 July 1929. Dreary and squalid though the town may be, the environs are delightful, for it is only a day's march to the wooded valleys of the mountains. Travelling in the Tien Shan is always peculiar because of the truly prodigious number of passes that have to be crossed, and the reason is always the same, namely, the narrow deep canyons which are so persistent a feature of this range. Travellers who complain of the narrow valleys of the Himalaya would be greatly harassed by the gorges of the Tien Shan. The difficulty of travel in them is seen by the immense detours laden animals take sooner than face the difficulties of these mountain tracks.

Deluges of rain had fallen at Urumchi, and we left during a break in them, hoping foolishly for fine weather. The Dzungarian plain merged gently, almost imperceptibly, into the foothills, and for the first two days led through farms surrounded by fine crops largely grown without irrigation, as the rains are copious here. The valleys of the Tien Shan are so deep and fissure-like that the water is useless for irrigation until it reaches the plains.

Undulating over low green but rather uninteresting spurs, the track descended, with that trick of sudden contrasts peculiar to Central Asia, into

the lovely Chowshih Tzu (Damp Stone Watercourse), with a fine growth of poplars, willows, and spruce. Climbing out of this, we reached the grassy yailaq (grazing-ground) high above the valley, with a perfect view over the Bogdo Ola, 35 miles away. The road then crossed the Kara Dawan (9700 feet) and wound down a very narrow valley into the Yapsar Salasai, where it poured for two days. In the Northern Tien Shan there are certain compensations to an enforced halt: mushrooms, wild spinach, rhubarb, and a kind of "greens" beloved of the Kashmiri, are abundant.

The route then ascended the Tutung Ho (First Series river), which was narrow and difficult for pack-animals, with high red cliffs above, frowning on the exuberant growth of willow and spruce. We passed by a wide stretch of bright green lawn between the tumbling river and the deep forest, and here we saw a dozen auls of the Kasai Qazaqs. A herd of yak, unknown in the Tien Shan, were grazing here. They belonged to a Tungan who had brought them from Kobdo beyond the Altai, as the owner had fled when the red flag of liberty was unfurled in Outer Mongolia. Leaving these nomads, we traversed broad and rich pastures to an easy grassy saddle, the Shara Dawan (Yellow Pass), height 9550 feet, with a splendid view.

It is one of the annoying customs of the nomads to give the same name to two different streams which unite farther down. The Tutung Ho was thousands of feet behind us, a high pass had been crossed, yet the stream and valley on the other side bore the same name. This topographical nomenclature leads to inextricable confusion, which is complicated by the poverty of the available place-names—common everywhere throughout Central Asia, and nearly meaningless in cases like this. It is due to the people, whether nomad or settler, never leaving their homes. As a Taranchi of the district said with pride, "We never travel. It is not our custom." Their stay-at-home habit is disastrous geographically, and results in hundreds of names almost useless for identification.

Leaving this second Tutung Ho, we descended to its junction with the Cholunger Sala (Stone House Valley), and followed them to its source. Where the Cholunger joined the Tutung Ho there was a long precipitous canyon through which the stream hurled itself with a roar. As we continued up the valley, crossing and recrossing the boulder-filled stream with some difficulty, we were struck by the lovely scenery, which surpassed any we had seen before. It was a steady ascent until near the head of the valley, when grassy stretches appeared. Camping at the foot of the Tengri Dawan, we crossed that pass on July 11. This pass (height 11,700 feet) has a very evil reputation, and long detours are made to avoid it. There was still snow on it, and it took several hours to reach the top, but on the northern side the gradient is nowhere really severe. On the southern side, descending into the long grassy Lopdong Ghol, the feeling was that of going down the side of a house, and in the reverse direction pack-animals could only do it by relays. The views from the top were fine and extensive. Although these passes had been crossed we had not passed over the watershed of the Manass river, and were thus still north of the Tien Shan. Leaving the pass we descended precipitously for 1200 yards, and after several steep patches we camped at Babaghai Sala (Wife's Valley). There was not a soul in sight, but our four best horses were stolen that night, and although we pursued

Qara Köl, Eastern Tien Shan

Cholunger valley leading south to Tengri Dawan

UNIV. OF UTAH

Looking south up valley to Shara Dawan

Head of Cholunger valley, north side of Tengri Dawan

the thieves, who were Torgut Mongols, we never managed to recover them. We noticed many abandoned gold workings at Babaghai Sala, and it was difficult to say why they had been abandoned.

The loss of four horses was very serious. In the days of the old Governor a horse thief was promptly executed, and very rightly. However, we managed to push on, but the riding-ponies had to carry packs. Turning nearly due south we crossed the Asak or Burukstai Dawan, height 11,850 feet, and in pouring rain we descended to the foot of the valley. From here, after retracing our steps over the Kukkhatin (worm or insect) Dawan, a grassy col, then into Durut or Durbut Dawan, 10,100 feet, then the Ulan Moron (red horse) Dawan, down the Kunde Khoro valley, over the important Zagastan (fish) Dawan, 10,400 feet, the Sagasutai of Stieler, we arrived at the head of the Great Yulduz (the word, strictly speaking, is Zulduz, or plain), and camped at Pöntsök Gegen, the Regent's headquarters. He was very civil and attentive, and replaced the four stolen horses, as is the custom of the country. I am afraid we hardly benefited by the exchange.

The headquarters of the Regent was a pretentious house built in the Russian style, but the auls of the lamas and chief Mongols and the tents holding the sacred images were more interesting. The camp was in a plain at the mouth of a side valley running out of the plain of the Great Yulduz itself. The latter is truly objectionable in summer, as flies of all kinds, but especially the large green-eyed horse flies and the mosquitoes, make life intolerable. The summer however is a short one, and the Regent only stays three months, as snow falls in September.

The Yulduz is nothing more than a magnificent grazing-ground. The low insignificant rounded hills, the wide grassy plain watered by a sluggish river, the complete absence of tree, shrub, or bush, and the treacherous climate with its detestable wind, the insect pests, and the rawness of the whole aspect make the Yulduz universally disliked by all except the nomads. Far better the real desert than these bleak uplands, deceitful with their fat pastures and devastating with their attendant evils.

Leaving the chief's headquarters, the route crossed the Khaidik river, which drains the whole Yulduz and falls into the Baghrash Köl, or Tengris Nor. The ground was swampy, but the river itself was easily fordable. A long stretch had to be traversed before the mountains were reached, and we were escorted by clouds of green-eyed horseflies which swarmed round man and beast alike, stinging and buzzing. The weary pack-animals bustled along as they had never done before, but it was only when we reached the top of the Tilahmad Pass that we managed to shake these insects off, which are always a serious menace to horses, and often cause death from loss of blood; indeed, it was owing to them that about 300 or 400 square miles of fine pasture were derelict.

The rest of the journey is soon told. The track entered the grassy but desolate Kuikunikin valley—the name means "the maiden's breast"—and a mile above the junction of the Ehkin Sala with the main valley, turned to the left up the Dawan Usun and crossed the Kuikunikin or Arche Dawan (11,200 feet). It is possible to continue up the main valley and avoid this pass, but the track is so rough that the pass is preferable. It is this pass which apparently figures on the maps as the Kuikul Pass, and which could not be identified anywhere else.

Descending the Shara Sala ("Yellow Valley") from the pass, the track led up a rough forbidding side valley and climbed rather steeply to the Dönde or Mulakchi Dawan (height 10,500 feet). The track then dipped into a valley, crossed the Arakwaste Pass, which at that height is only a col, and rose slightly to the Tilahmed or Noryn Dawan (height 10,800 feet). These three passes were close together and in a line—all visible from each other. It has been claimed that the Kuikul Pass is really the Tilahmed, but it can only be repeated that we failed to identify either name or pass, and certainly did not do so with either the Kuikunikin or the Tilahmed passes. The descent from the Tilahmed was very severe. It is a most difficult and dangerous pass at certain seasons, and Captain George Sheriff, H.B.M.'s Vice-Consul at Kashgar, lost his caravan and nearly all his party when caught in a snowstorm there in October 1928.

Passing the glades and park-like country near the lake Qara Köl—not to be confused with the other better-known Qara Köl in Russian territory—we crossed the Qaraghai Dawan (8400 feet) and skirting and then fording the Kucha river, where the scenery at Qurghan was fascinating, we crossed the Qirghiz At Dawan (Qirghiz Horse, after a huge peak so named), height 8950 feet, and in due course reached Bai, a little too early for the melons, but in time for plenty of apricots, peaches, and nectarines—very welcome and much appreciated after a diet of meat and stringy rhubarb.

In conclusion, the following observations may be made. The climate of the Tien Shan is most uncertain. At no season of the year can any fine weather be depended on, as is the case in the Himalayas. Now this is a most serious matter for the traveller, who is thus obliged to be always anxious about supplies. The changes in weather, too, are unusually rapid and capricious, and no reliance whatever can be put on conditions which would indicate in other countries' mountain systems some days of settled weather.

The bleakness and inhospitable nature of the Yulduz is not easily explained. The chief's yamen was only 7550 feet above sea-level, yet no trees would grow, even though carefully tended, and the few vegetables were most troublesome to cultivate. It is well known that Rupshu, the Pamirs, the Altai, or parts of the same Tien Shan south or north of the Yulduz, and other inhabited altitudes, carry trees, brushwood, and certain crops; but all the attempts to grow anything in the Yulduz have failed. It is due, however, to no defect in the soil. The only suggestion, and it is not a very convincing one, is that the wind is harmful to vegetation.

Reference must be made again to the canyons of the Tien Shan. On both sides of the main northern range, and also in the southern, these deep fissures were the feature of the mountain structure. Their effect is considerable, because it is owing to them that Dzungaria is cut off from the south, and that pack-animals have to cross the Muzart Pass, with a difficult and shifting glacier, as the sole alternative to going round by Urumchi.

Haze is very bad in the Tien Shan, and parts of the Yulduz plains looked as if some London fog had swept up the valley. This is a further complication to the traveller, who may be pardoned if he sometimes becomes exasperated by the churlishness of the climate.

A final remark with regard to the nomenclature of this region is desirable. The whole district is inhabited by a variety of races, and each gives its own

name to the local features. The consequence of this is that there are several names to one place, and these names are often used indifferently; for example a Qazaq will use the Mongol name, and, though less frequently, a Mongol will use the Qazaq or Sart name. There is, though, a tendency in the case of important features for one name to be the most general and others gradually to drop out. This, however, does not do away with, but merely mitigates the confusion; and it is this variety of synonyms, coupled with the poverty of place names, that makes the identification of points so difficult. The extremely bad transliteration of the Russian maps has also to be considered (Chinese names in particular suffer most in the process of Russification) and the clumsy German spelling makes the muddle still worse. In the homogeneous Turki districts of the Tarim basin, Achiq Bulaq, Aqsu, Jigda Bulaq, and the like are met with at every turn, but when the same few names are turned into Mongol, Chinese, Qazaq, and the rest, the result is devastating.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: Since we last met we have all learned, with the deepest regret, of the death of two of our most distinguished Honorary Corresponding members. I allude to the death of Dr. Nansen, that world-famous explorer and man of science, who twice received a Gold Medal from this Society, whose name is world-wide and whose ability was only equalled by the amiability of his character; and also to the death of Mr. Hotz, so well known as a student of the history and geography of the Near East, who was a benefactor to this Society, having left us a large number of very valuable and interesting books as an important addition to the Library. The Council has, in the name of the Society, sent messages of sympathy to Madame Nansen and to Madame Hotz.

Turning to the subject of the lecture, I may remind you that though this year we have had a varied fare, we have heard more of Asia than of any other continent. We have had accounts of the Karakoram, of the Himalaya, of Northern Burma, of North-West Manchuria: in fact, about nine lectures dealing with Asia, chiefly with Central Asia and the great backbone of the continent.

Colonel Schomberg, who is our lecturer this evening, has given us two papers already, one published in the *Journal* for December last on the Tarim basin, and another, read at a recent Afternoon Meeting of the Society, in which he gave pretty conclusive reasons why we should give up the notion that that part of Asia is gradually being subjected to desiccation.

He will lecture to-night on the Tien Shan, which, as you know, is to the north of the Tarim basin. He has been there three times and will give us a condensed account of his three journeys. The Society thinks highly of his work in Central Asia, and recently awarded him the Gill Memorial, the presentation of which is reserved for June 23. By that time Colonel Schomberg will be once more on his way to Central Asia, and perhaps the only means of presenting the award to him personally will be to call on the services of Miss Amy Johnson. However, we wish him all possible success in his new journey. Meanwhile, we shall be glad to hear what he has to say about his three journeys in the Tien Shan.

Colonel Schomberg then read the paper printed above.

The PRESIDENT, having without response called upon two travellers present to open the discussion, said: If there is no one else who has been in the Tien Shan

I should like to ask the lecturer two questions: first, is the word "Tien Shan" known locally over the whole of that region, including the two branches?

Colonel SCHOMBERG: Not by the nomads, but by the Chinese.

The PRESIDENT: If you say "Tien Shan" they know what you are referring to?

Colonel SCHOMBERG: Yes.

The PRESIDENT: What is the height of the mountains in the Tien Shan?

Colonel SCHOMBERG: Manass peak is about 24,000 feet.

The PRESIDENT: And the hills you showed?

Colonel SCHOMBERG: About 21,000 feet.

The PRESIDENT: We have listened to a lecture on a part of the world which very few of us know anything about. Colonel Schomberg is gradually exploring that region which, I take it, is about 150,000 square miles in area. It is an area which deserves exploration because the existing maps, which are largely based on Russian material, are to a great extent worthless. I understand it is not by any means easy to do the mapping which is necessary, but we shall hope, bit by bit and as the result of Colonel Schomberg's journeys and perhaps those of others, soon to know a little more about the region. It is possible to make some kind of map if one has only a few points to go on. That is the great difficulty. If you take photographs and know where you are pointing and have one or two points in the photography you know something of, you can construct something of a map. But we have not much of a framework at present. Meanwhile, we are getting as much information as possible from Colonel Schomberg. We do not know where he is going to next time, but we hope he will carry on his explorations in that relatively little-known part of the world. I am sure we all wish him good luck in his next expedition, and we thank him heartily for his lecture.

RIVER-FLOW RECORDS: *A paper read at the Afternoon Meeting of the Society on 20 January 1930, by*

W. N. McCLEAN, A.M.INST.C.E.

1. *Introduction*

RIVER-FLOW is only one aspect in the general survey of our country's water resources; but it is something which is definitely measurable, and its measure plays a most important part in the development of civilized countries, whether for navigation, irrigation, or fisheries, scouring or prevention of pollution, water supply or power, or for condensing water for electricity-generating stations. In most cases it goes unmeasured from its source to the sea.

In this country two measurements which concern river-flow have been accomplished with a high degree of efficiency: geographical survey of river basins and distribution of rainfall. It is the high efficiency of these two measurements which has allowed estimates of river-flow to be made with some degree of accuracy and which has consequently staved off the direct measurement of flow. Many observations and experiments have been made in the attempt to determine the losses which may occur between precipitation and flow-off; but, rather obviously, the only method of arriving at such losses is by the measurement of flow.

Now, there is sufficient evidence that, with one rain-gauge to about 10 sq. miles, the mean rainfall on an area may be gauged to about 5 per cent. for yearly periods, although for shorter periods the error may be much greater. Thus the value of the rainfall measurement is in the ascertainment of the distribution of rain over a catchment area, and each tributary stream may be allotted its proportion of the rainfall. On the other hand, the measurement of flow is a concentrated one, giving at one point the whole information required; but it cannot usually be made for all the tributary streams.

Thus as an example consider a large catchment area on which the mean annual rainfall, flow-off, and apparent loss are, after several years of observation, found to be 50 inches, 40 inches, and 10 inches respectively. Assume also that the rainfall distribution on one half of the area is known to be 60 inches and on the other half 40 inches. By applying the same figure of 10 inches for apparent loss it may be fairly reckoned that the mean annual flow-off on the two half areas is 50 inches and 30 inches respectively. Therefore the long records of rainfall and their comparison with flow-off are of great value.

The rain-gauge is necessary for the measurement of rainfall incidence, quite apart from its use for measuring water resources, and it gives a simple and direct measurement; whereas the recording of water-levels is only a means to an end, and much expert work has to be accomplished before the resulting records of flow can be obtained. But however necessary the rain-gauge, the measurements of flow are the only absolute measure of the water available in rivers and streams; and they are often a better measure of rainfall than rainfall is of river-flow.

The object of my work on river-flow is (1) to establish continuous records of water-levels at important points; (2) to measure the actual flow at different

water-levels; and (3) to make the best possible comparison between rainfall and flow-off.

There are numerous works on river-flow of a very high order, as, for instance, the final *Report on the Investigation of the Rivers Severn, Exe, and Medway*, published by this Society in 1916. There are many papers in the proceedings of the Institutions of Civil Engineers and of Water Engineers. The measurements of the flow of the Thames and Severn are maintained and water undertakings often keep valuable records of rainfall and of flow, which unfortunately are usually secret. After the war a Royal Commission reported on the Water Resources of the British Isles for Power. The Report covers most of the principal areas, but is almost entirely based on rainfall data. That Commission recommended systematic records of water resources by flow- and water-level measurements, but no progress has been made excepting an attempt to organize Regional Water Committees. Other countries are far ahead of us with these measurements.

A work such as Sir John Murray's survey of the Scottish Lochs was accomplished for the benefit of science, and the early efforts of Mr. G. J. Symons developed into the British Rainfall Organization; surely it is time that surface and underground water-levels and the flow of rivers reached a high standard of record with the co-operation of all our engineers.

2. *The Data available for Water Engineers*

In this paper I am dealing only with rivers and their catchment areas and not with underground sources of water supply. In the latter case water-levels are the principal basis of measurement, as the catchment area is unknown.

When the engineer wants to design a scheme for the use of surface water and looks around for information, there are firstly the Ordnance Survey sheets, which give the catchment area and the land-levels and the natural or artificial storage sites; there is also considerable information available from the Geological Survey; and lastly the Meteorological Office will supply him with the mean distribution of rainfall on the area and with information as to the fluctuations of annual and monthly rainfall. He may therefore calculate, with some degree of accuracy, for different lengths of period, the rainfall on the whole or any portion of the catchment area. After that he must make suitable deductions for evaporation, absorption, etc. Clearly there will be some very doubtful figures in his estimate of the available supply.

A usual assumption is that the rainfall of the driest year is 65 per cent. of the average, and of the driest three years 80 per cent. of the average; in different parts of the country the first figure may vary between 50 per cent. and 75 per cent., and the latter figure between 78 per cent. and 90 per cent. Dry periods of seven to ten months are very important, and the rainfall data for such periods are not easily obtainable. For annual losses, 14 inches is quite a usual figure to adopt; but on one large water supply the loss has been found to be 20 inches or more each year. At different seasons of the year the losses will vary greatly, and in many cases there is an apparent excess of flow-off in the winter and early spring.

On such information schemes of water supply are sanctioned and compensation water fixed; and it is, generally, only at a later date that actual flow measurements are made, preparatory to designing the works. With organized measure-

ments of flow the necessary water data will be available before a scheme is sanctioned.

It will be many years before flow measurements can become valuable records, and in the meantime the long records of rainfall fill the gap. Rainfall records have increased greatly in number since the early days, and in a similar manner the records of water-level and of flow will extend and improve under proper organization, which should be by area committees. The perfection of the modern current-meter and other water-gauging instruments should do much to establish flow measurements.

3. *The Mass-Rate Diagram of the Rainfall and Flow-off of the River Garry Catchment Area*

The diagram (Fig. 1 on folding sheet following p. 96) is a continuous graph of the flow of the river Garry and of the rainfall on its catchment area; and the effects of any substituted flows may be studied on it and the necessary storage may be estimated; and to some extent with the help of long rainfall records the flows of other periods may be estimated.

During the three years 1913, 1914, and 1915 water-levels were recorded continuously, by an automatic gauge, on the river a short distance below Invergarry road bridge. The measurements of river-flow were taken there on thirty-three occasions during 1913 and covered all flows excepting high floods and very low flows; and thus at any time during those three years the flow is known in cub. ft. per sec. or "Cusecs." For each day the total flow-off was calculated and expressed as so many inches in depth on the catchment area of 150 sq. miles. Approximately 400 cusecs gives a daily flow-off of one-tenth inch on the area.

On the diagram the lower continuous graph gives the aggregate flow-off from 1 January 1913 up to any date during those three years; hence the term "Mass" is applied to this graph. But an aggregate or Mass-graph cannot be plotted on an ordinary sheet of paper on a scale large enough to be of any value; and therefore for plotting, the aggregate is expressed as an excess or deficiency from some convenient rate; hence the term "Rate" is also applied to the graph.

In this case the chosen rate is 91·04 inches per annum because the graph is for rainfall and flow-off; and 91·04 inches is the average rainfall of the three years on this area. Any other rate, such as the average flow-off, might have been chosen. This chosen rate is represented by the horizontal line passing through the zero of the rainfall graph on 1 January 1913. It will be observed that the flow-off graph starts about 4 inches below the rainfall graph, and that is because there was a large remaining flow from 1912 on its way down the river.

Thus, following the flow-off graph, we may consider any desired period during those three years; the inclination of the straight line which joins the beginning and end of such a period will represent the average rate during that period; and the vertical heights from the graph to that line will at any intermediate date give the excess or deficiency of the flow-off from the average of that period.

The use of this diagram to the engineer is to compare the natural flow with the controlled flow which he proposes to substitute for it, and to find at any time the storage which is required to balance those two flows and which will be given by the vertical heights between their graphs. If there are no flow measure-

ments, the engineer must construct the natural flow-off graph from the rainfall graph by assuming apparent losses.

When a reservoir is full after a wet period the graphs of natural flow and of controlled flow will coincide for the duration of overflow; when the natural flow falls below the controlled flow depletion of the reservoir commences and continues until the aggregates of the two flows are once more equal and their graphs again coincide. When the depletion has gone on until the reservoir is empty, then the controlled flow will drop to the natural flow and its graph will be parallel to that of the natural flow. Therefore in order to determine the necessary storage the engineer must know the maximum extent to which the natural flow-graph may fall below the controlled flow-graph. This may be solved conveniently by assuming that the commencement of depletion, after overflow has ceased, is followed by the lowest possible flows of any length of period. These lowest flows of any length of period can only be obtained from a long record which is seldom available for flow-off, and therefore must be constructed from the rainfall graph. Herein lies the obvious necessity for continuous records of flow on principal rivers.

Let us take the case of the Garry, and calculate the necessary storage by finding the depletion which will occur during the driest periods of different lengths. Assume that the controlled flow is to be that of the driest twelve months. Then, since there are no long records of flow-off, we must take the lowest rainfall of twelve months, that is 62·51 inches, and make a deduction for the likely loss. This deduction must be ample, and after a full examination of the losses during these three years I find that 50 inches is a proper value to assume for the lowest possible twelve months flow-off. I also find from the rainfall records, combined with the losses indicated from these three years, that the following table gives the lowest possible flow-off for the different lengths of periods up to twelve months.

Length of Depletion Period	*Controlled flow*	*Lowest natural flow-off*	*Maximum deficiency*
1 month	4·17 ins.	0·29 ins.	3·88 ins.
2 months	8·34 ,,	1·09 ,,	7·25 ,,
3 ,,	12·50 ,,	2·42 ,,	10·08 ,,
4 ,,	16·67 ,,	4·44 ,,	12·23 ,,
5 ,,	20·84 ,,	7·29 ,,	13·55 ,,
6 ,,	25·00 ,,	10·65 ,,	14·35 ,,
7 ,,	29·17 ,,	14·98 ,,	14·19 ,,
8 ,,	33·34 ,,	*21·38 ,,	11·96 ,,
9 ,,	37·50 ,,	28·36 ,,	9·14 ,,
10 ,,	41·67 ,,	35·19 ,,	6·48 ,,
11 ,,	45·84 ,,	42·43 ,,	3·41 ,,
12 ,,	50·00 ,,	50·00 ,,	Nil

Thus 14·35 inches on the area is the storage required to assure a controlled flow equal to that of the driest twelve months. If the reservoir is of this capacity the period of depletion cannot exceed twelve months, and the maximum depletion if reached will occur between six and seven months after depletion has commenced.

A further examination of the records shows that until a controlled flow of

*This is very little lower than the flow-off of 1915.

64·4 inches per annum is reached the maximum depletion will be reached only during the first year after the commencement of depletion; but that for a larger controlled flow it will occur during the second year. The maximum depletion for the 64·4 inches flow would be 21·6 inches. The period for maximum depletion would not reach the third year unless the controlled flow were increased to 66·91 inches per annum, with a maximum depletion of 25 or 26 inches. These values are obtained from a diagram of lowest rainfall and flow-offs constructed from the long rainfall record of Glenquoich Lodge and from the three years' measurement of flow-off. Rainfall, as well as flow-off, plays an important part.

Let us examine now, in some detail, the construction of the rainfall graph which shows the estimated daily rainfall distributed over the area. It will be apparent at once that, if there are sufficient gauges on the area, each rain-gauge may be allotted a certain portion of the area and the mean daily rainfall on the whole area will be given by the equation :

$$R \times A = R_1 \times A_1 + R_2 \times A_2 + R_3 \times A_3 + \text{etc.} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

But if there is only one rain-gauge on the whole area the daily distribution on the area can only be taken as some percentage of that gauge. The mean daily rainfall on the whole area is then given by the equation:

$$R \times A = \text{Const} \times R_1 \times A \text{ or } R = q\% \times R_1 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This means that the distribution on the area is assumed to be the same for each day, which of course cannot be correct. The best possible value of q is obtained from a mean annual distribution map prepared by the Meteorological Office.

In my survey of the Garry there were thirteen gauges of which one was the long record of Glenquoich Lodge: about 1 gauge to 12 sq. miles. I allotted areas as in equation (1) and I also obtained a mean annual distribution map from the Meteorological Office, and I altered that distribution slightly in order to make the map agree with the rainfall of the individual gauges. For each year I calculated R from equation (1) and substituted that value in equation (2), obtaining for each year 86·8 per cent., 83·5 per cent., and 84·6 per cent. respectively as the values of q, or a mean value of 85 per cent. Thus, for the three years, equation (1) was used for estimating the daily rainfall distribution; and for the back records of Glenquoich Lodge the distribution was taken as 85 per cent. of Glenquoich.

When monthly periods were considered instead of yearly periods the value of q varied between about 60 per cent. and 100 per cent. This shows that the rainfall graph may be taken as pretty correct for long periods, but that for short periods there may be considerable error. This of course is all in favour of the measurement of flow being observed rather than the measurement of rainfall.

The main characteristic of the rainfall on this area, other than its magnitude, is the summer and winter variation. The annual average is 110 inches at Glenquoich, but only 40 inches of this amount falls during the six months April to September. This seasonal effect is apparent on the graph and is emphasized by the rate line which represents the rainfall rate, 62·51 inches per annum, of the driest twelve months in forty-five years. This rate is 67 per cent. of the average annual rainfall on the area. The year 1915 provided the driest seven to ten months on record; and the calendar year with 70·71 inches was also the driest on

record, although it was 8 inches in excess of the driest twelve months on record in 1894–1895.

Passing to the actual comparison of rainfall and flow-off, the vertical heights between the two graphs give the apparent loss of rainfall, and, at suitable points of comparison, these verticals are subdivided in order to show (1) the loss of the short preceding period; (2) the so-called cycle loss; and (3) the remaining flow before low water would be reached. The short periods are selected from one low water to the next, so that the remaining flow may be as small as possible; and the remaining flow is calculated from the usual rate of the river fall after the cessation of rain. Thus the flow-off of each rain period is estimated as nearly as is possible. These short period losses are very irregular, and undoubtedly the uncertain measure of daily distribution of rainfall is the principal cause.

The cycle losses are the aggregate of the short period losses, commencing in the spring after the melting of the snow and continuing till the same period of the following year. On these catchments, where complete saturation takes place every winter, this period of cycle appears to be the best.

For a period in July 1915 the loss of the period is distributed uniformly over the period, as shown by the lower shaded area; and the upper shaded area shows the rainfall in transit or unexpended rainfall on any day. Each period might be treated in a similar manner; and the unexpended rainfall has been shown during a few of the larger floods and occasionally amounts to as much as 6 inches.

The Construction of the Diagram

Figure 3 is an enlarged detail of the Mass-Rate Diagram for the sub-period June 21 to July 26, 1914.

These sub-periods or rain periods lie between two dates of low river occurring, preferably, after several rainless days. At the commencing date the whole vertical between the graphs of rainfall and flow-off gives the aggregate excess of rainfall over flow-off to that date, but some of the rainfall, termed unexpended rainfall, has not appeared as flow-off at the gauging site.

It is assumed that any rainfall on the two previous days, in this case 0·04 inch, has not affected the flow-off. Also from an examination of general drop in the river flow during rainless or nearly rainless days it is possible to estimate, approximately, the further flow-off which would occur before a standard low river is reached. In this case the remaining or tail flow-off is 0·22 inch.

Thus, there is a total of unexpended rainfall amounting to 0·26 inch on June 25, and this is shown as a deduction from the aggregate rainfall, leaving a total loss to date of 11·52 inches of which 3·03 inches is the loss of the second cycle since its commencement on May 3 and 8·49 inches is the total loss prior to May 3.

The term loss is, strictly speaking, apparent loss, because, in many ways and at different seasons, some of that loss may reappear as flow in a later sub-period and, consequently, reduce the loss of that sub-period. The up and down of sub-period losses will depend on all the local characteristics of a river catchment.

At the finishing date of this sub-period, July 26, the same procedure is followed and the total loss has increased to 12·86 inches, raising the cycle loss to 4·37 inches of which the sub-period loss is 1·34 inches. This sub-period loss has occurred during twenty-six days, and it is only possible, diagrammatically, to spread it uniformly over the period. Thus, on any day of the sub-

period, we may deduce approximately unexpended rainfall as being the remainder of the vertical height between the flow-off and rainfall graphs after deducting the loss of the sub-period up to that day and the total loss of 11·52 inches prior to the sub-period.

The general principle is thus first to determine the data at the critical low river dates and then to interpolate for intermediate values. Where there is large temporary storage, as in Loch Garry, the unexpended rainfall may reach a high value. The construction is similar when there is a sub-period gain.

I have mentioned the irregularity of the losses during short periods and it is interesting to find that during longer periods these irregularities disappear. Thus for the driest six months of each year:

1913	shows a loss of	6·71	inches	on a rainfall of	26·68	inches
1914	,,	,,	7·38	,,	,,	,,	28·00	,,
and 1915	,,	,,	6·32	,,	,,	,,	18·81	,,

I have made similar rainfall graphs for thirty-five Scottish gauges with long records, and I have extracted from them and graphed the aggregate rainfall of the driest periods of different lengths for one, two, three months, etc., up to thirty-six months, and then for each quarter year up to six years. This was done with the object of forecasting lowest flows either by the deduction of arbitrary losses or by a comparison of flow and rainfall such as has been done on the Garry. So far as the river Garry is concerned the three-years' measurement of flow may suffice because there is complete saturation each year; but for rivers such as the Thames and Severn a much longer period of flow measurement, coupled with records of underground water-levels, would no doubt be necessary.

There is of course a serious objection to unqualified use of long records because it is difficult to judge their accuracy, and it would be well if some systematic area supervision could be organized for rainfall and water-level observations.

4. *Flow Measurements on the rivers Garry and Moriston*

Loch Ness holds $1\frac{3}{4}$ cubic miles of water—three times the volume of Loch Lomond. It would take three years of rainfall to fill it. It collects the rainfall of 700 sq. miles, and probably two-thirds of that rainfall falls on the 300 sq. miles of the Garry and Moriston.

The mean annual rainfall on the Garry area of 150 sq. miles is about 97 inches, and on the Moriston area, also of 150 sq. miles, is about 80 inches. At the head of the Garry the rain-gauge shows an annual average of 164 inches and at Invermoriston 50 inches.

Fig. 2 is a map of the whole Ness catchment including both the Garry and Moriston. The map shows the contour lines of equal rainfall given by the Meteorological Office and the sites of the rain-gauges used in my 1913 survey and in the present survey. It also shows the water-level recording stations now in action on the Rivers Garry, Oich, Moriston, and Ness and on Loch Quoich, Oich, and Ness, and the flow gauging sites on the four rivers.

Plates 1 and 2 show the falls of Garry at the exit from Loch Garry at low water and on a medium flood. The long narrow exit piles up the floods on the $1\frac{3}{4}$ sq. miles area of Loch Garry as high as 20 feet, thereby storing 3 inches of

rainfall from the 133 sq. miles of catchment. This causes some forty-eight hours' delay of the floods below and maintains these floods for many days. It is probable that the impounding of Loch Quoich, combined with the natural control at this point, would maintain any desired moderate and low flows on the lower river Garry and reduce the floods to about one-quarter of their present volume.

Loch Quoich (Pl. 3) is perhaps the richest "white coal" site in Scotland. An average annual rainfall of 120 inches falls on the 50 sq. miles catchment and is collected in the Loch, which is $2\frac{3}{4}$ sq. miles in area, and 280 feet in depth; its surface is 550 feet above the sea-level in Loch Hourn, which is only 4 miles distant. With a small length of dam this Loch could be raised 100 feet if required, and store the equivalent of 72 inches on the catchment, which is equal to the entire flow-off of the driest year. Water-levels are being recorded at Glenquoich Lodge, where a rain-gauge record has been kept since about 1870; and at any time flow measurements may be made on the river below the Loch and give an accurate assessment of this unique water area. Lochs Loyne and Cluanie, in the neighbouring valley of the river Moriston, are respectively 700 and 600 feet above sea-level and collect the water of 56 sq. miles; but the rainfall is rather less than on Loch Quoich, and the lochs are of smaller area. By a series of rocky falls at Invermoriston Bridge the river descends 100 feet into Loch Ness (Pl. 4).

Plate 5 shows the gauging of the river-flow at Invergarry in 1913. These measurements were made for me by Mr. H. Chapman with the assistance of Mr. Lutyens and Mr. Laidlaw, and I regret to say that the latter two lost their lives in the Great War. An automatic "float" water-level gauge was set up on a small wooden pier and the record was maintained for the three years 1913, 1914, and 1915. The current-meter rod was lowered to the bottom of the river by the operator on the bosun's chair and the meter was then lowered to the required depth. Gaugings of the river were made on thirty-three occasions during 1913 between flows of 100 cusecs and 4000 cusecs. The apparatus did not allow of other than surface flows being observed in the high floods.

Plate 6 shows the gauging in operation in 1929 on the same site as in 1913. The water-levels are being recorded on a gauge-post twice daily, and on an automatic gauge. The latter is a compressed air gauge, with an air-box and diaphragm fixed under water and connected by a pipe of small diameter to the recording apparatus. It is a moderate-priced gauge, easily set up, inconspicuous, and secure against damage and interference. Its accuracy is only moderate, but combined with gauge-post readings suffices for its purpose of giving a good average daily reading of water-level. A main wire cable was stretched across the 75-feet width of river at a considerable height above the water-level. The head ropes of the punt were fastened to a small trolley which, by means of an endless rope, could be moved along the main cable to any desired position across the river. The punt was steadied by a light line across the river. The Amsler Current Meter rested on a collar 6 inches above the bottom of the rod, which was free to move up and down in a specially designed bracket on the bow of the punt. A tally line downstream of the main cable gave the position on the river, and the meter rod was brought up to this line by means of the head ropes of the punt. An electric bell rang for a fixed number of

2. Falls of Garry: medium flood

1. Falls of Garry: low water

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3. Loch Quoich

4. Top of the falls at Invermoriston Bridge

revolutions of the current meter and the times between rings were recorded by a stop-watch. Prior to the measurements, and after their completion, the meter was tested in the Froude Tank at Teddington. Generally speaking, the velocities were measured for each 6 inches of depth at every 5 feet across the river, and four or five rings were timed at each depth. For flood measurements this is undoubtedly the best site available on the river, but it is too deep and too slow-flowing for very low water measurements. These will have to be taken at a different site. In 1929 flows between 700 cusecs and 1700 cusecs were measured on seven occasions, and the rise in water-level between these flows proved to be the same as in 1913.

The weir at the exit from Loch Oich maintains the water-levels for the summit of the Caledonian Canal. The low flows pass through a small fish-pass which, if the crest had been unbroken, might have yielded values of low-water flow by the use of a formula. Plate 7 shows the gauging of the river Oich below the weir, which was undertaken principally to obtain measurements of low flow. In this case a main cable was not used, and the endless rope was attached direct to the front of the punt and a steadying rope used on the stern. Unfortunately the summer of 1929 did not yield any very low flows—nothing comparable with the low flows of the early spring.

Plate 8 shows the gauging section of the river Moriston about 1 mile above Invermoriston Bridge. It is in the long pool above the falls (Pl. 4) that I hope to measure the flood flows. No stream of any size enters the river in the 1 mile between the two gauging sites. Water-levels are being recorded at both sites and the gauges are being carefully compared at different stages of the river.

At the upper site flow-gaugings were taken on seven occasions in September, covering a range of flow between 140 and 1800 cusecs. The Moriston, unlike the Garry, is an exceedingly flash river, and the peak of the floods appears to reach a very high figure. Mr. H. Chapman was again responsible for the measuring work, and most of the photographs were taken by him. There was also considerable levelling work, and the irregularities of the Ordnance Survey Bench Marks added considerably to the task.

It is necessary to add a few words on the methods of arriving at the values of the flows. The gauging of a section generally takes the best part of a day, and during that time the water-level varies; but it does not vary appreciably during the measurements of velocity at one point on the section. The principal aim in the measurement was therefore to return to the same gauging point on each occasion, and the tally-line allowed of this being done with considerable accuracy. For each gauging the velocities in each vertical were plotted, and these velocity diagrams were placed relatively to their position on the river. From each of these velocity diagrams the cusecs passing each vertical (for 1 foot of width) were calculated and tabulated against the water-level. Then, on a large section of the whole river, points were plotted giving the cusecs passing each vertical at all observed water-levels. These points were then joined up and the cusecs obtained for each 1-inch variation in water-level. The Stage-Discharge-Curve follows therefrom. The whole system of calculation is depicted in a form such that the interpolations may be seen quite clearly and definitely. The likely errors due to bottom irregularity may be gauged from the velocity diagrams.

5. *The Records of River-Flow—Quarterly Reports*

I had to determine a form in which to record, from day to day, the water data obtained from all the observations and the flow measurements. It may be early days to record flows which are not in all cases final, but the recording of water-levels cannot be started too soon and cannot be too well organized. It is my earnest hope that water-level recording will be maintained when its value in deriving flows is realized; and I am endeavouring to visualize that local interest which will bring the necessary organization into being. In the meantime, as there are many who have been helping in this work in different ways and whose interest I desire to keep, I have decided on the Quarterly Reports, which, in addition to being records, would be a history of the progress of the work. [Copies of the River Moriston Report, July–September 1929, were circulated before the Discussion.]

The Reports in the main consist of three tables:

Table I gives the daily rainfall at the principal gauges on the area.

Table II gives the calculated river-flows at each stage or river height; and, as more measurements are made, there will be modifications of these flow figures.

Table III gives the mean river-flows for each day of the quarter and expresses both the rainfall and flow-off of each day as so many inches on the area. Lastly it gives the aggregate to date of rainfall and flow-off in order that the two measurements may be compared between any two low-river dates or for any other desired period and, in due course, provide valuable information as to both rainfall and flow-off.

These records are designed to include, finally, all the principal rivers of the Ness Basin, and the comparison of the flows of the several rivers should prove interesting.

6. *Organization of River-Flow Records*

I hope that all who are measuring flows may put their records together on some such lines as these, and that they will co-operate sufficiently to allow of a central recording office compiling quarterly, or at suitable intervals, reports on the various rivers. In time these measurers or recorders would each be responsible for the work on a large area, perhaps as much as 5000 sq. miles. The flows of the rivers would be regauged at five-yearly periods, and the whole apparatus and personnel of water-levels would be under their supervision. They would be in close touch with the regional water committees, when set up, or with River Boards. Their work would be supervised by some technical committee co-operating with, say, the Ministry of Health.

The principal object of the moment should be to assure the recording of water-levels on a really satisfactory basis. It is not quite sufficient to read twice daily an ordinary gauge post; in many cases continuous recording apparatus is necessary; and in all cases the gauge post should be substantial, easily read, and in a secure position. Then the gauging section should be carefully prepared. There would be little cost in keeping the necessary foundation ready for the erection of a standard trestle. It is no easy matter to set up the gauging gear on unprepared sites. A first difficulty is to obtain access to the river for gauging flows without interfering with the amenities. It certainly seems that access

5. Gauging with current-meter from the bosun's chair: Invergarry, 1913

6. Gauging from the punt at the same place in 1929

7. Gauging the Oich below the weir without a main cable

8. Gauging the Moriston about a mile above Invermoriston Bridge

should be arranged as with Ordnance Survey work. There need be very little, if any, interference with fishing.

Lastly there is the question of Water Rights and the fear that exact measurements will act detrimentally to existing rights. Certainly they may tend to stop one user from getting the better of another, but surely the honest user will be better off by having the data ready to hand and recorded by an independent authority.

The cost of measurement should not be a heavy item, and if, as with electrical research, Water Authorities and Undertakings financed Water-Resource measurements, the expense incurred would be offset by the saving effected in the promotion expenses and in the layout of the works.

I should estimate the cost of keeping a continuous record of a river such as the Garry, with a catchment of 150 sq. miles, at about £300 per annum. The cost would include: (1) Depreciation and maintenance of water-level gauges and observational and postal expenses. (2) Proportion of depreciation and maintenance of all river-flow measurement apparatus. (3) Expenses of complete flow measurements at five-year intervals. (4) Proportion of expenses of computing and recording staff. (5) Quarterly records of all the water data. One Recorder, complete with staff and gear, should suffice for all the work on some twenty-five rivers at an annual cost of, say, £7500.

The author trusts that he has shown that the recording of water-levels and flow at important points on principal rivers is essential for knowledge of our water resources and that the measurements are neither difficult nor costly.

DISCUSSION

Before the paper the PRESIDENT (Col. Sir CHARLES CLOSE) said: Before asking Mr. McClean to read his paper I should say, what is known to most of those present, that originally the paper set for this afternoon's meeting was one by Lieut.-Col. Schomberg on "Climatic Conditions in the Tarim Basin." He fell ill and was unable to come, so Mr. McClean has very kindly undertaken to open a discussion upon river-flow records. We all know that this matter of river-flow is intimately connected with the study of rainfall, and the combined investigations affect the provision of water supply for ordinary purposes and also for power. It has a very considerable importance nowadays, and we shall be glad to hear what Mr. McClean has to say.

Mr. McClean then read the paper printed above, and a discussion followed.

The PRESIDENT: Brigadier Jack wishes to read some notes given him by Captain Withycombe, who has experience in this matter.

Brigadier E. M. JACK (Director-General Ordnance Survey): I appear as deputy for Captain Withycombe, who is keenly interested in this subject and was very anxious to attend this meeting, but was prevented by illness. I will however read a short note he gave me; but I should explain that Captain Withycombe has not had the advantage of reading Mr. McClean's paper, so that his note on the report of the investigation of the River Moriston must be taken as applying to that only.

Brigadier Jack then read the following note by Captain Withycombe:

The systematic measurement of the river-flow and the co-ordination of run-off with rainfall is work which is very much overdue in this country, and such an effort as is being made by Mr. McClean should be cordially welcomed by every one

interested in the development of the resources of this country. One of the recommendations of the Water Resources Committee of the Board of Trade (1918–1919) was that all information relating to inland water should be filed in a central office and made available to all Government Departments and others interested. A model card-index and map-recording system was devised and published with the Report of the Committee, and that system has been adopted by the Department of the Chief Engineer for the Ministry of Health, and is now being used for the recording of water resources data.

There is no doubt that the method adopted by Mr. McClean is the one most likely to give satisfactory results, but it is a pity that he has not given more information as to his apparatus, etc., in his report on the River Moriston. A cross-section of the gauging of the river, the gauging station together with the description of the bed, and if possible a profile of the river from its source to its confluence with Loch Ness, would have been valuable additions to the report. With regard to the table giving flow-off and rainfall, it seems obvious that a great deal more metering will have to be done before a reliable rating curve can be constructed. Such metering as was done took place during September last year, after an exceptional drought, and I think it should be checked and confirmed by another series of measurements extended over as long a period of time as possible.

The gauging of the rivers and streams of Great Britain is work which should be undertaken by some organization which could keep a regular staff engaged in the field throughout the year. I would draw attention to the publications of the United States Geological Survey, which deal with water supply, and also to the water resources papers published by the Dominion Water Power Plant of the Department of Interior Canada. In both these countries the problem of relating rainfall to run-off has been carefully studied. The factors are so complex that it has been found impossible to lay down any general rule: for certain types of country a rough relationship can be established, but as a rule each stream is a special case. Soil, vegetation, geology, temperature as affecting evaporation, angles of slope, and size of the catchment, are all factors of the problem.

Brigadier JACK, continuing, said: Mr. McClean very kindly sent me a copy of the printed report on River Moriston and in his covering letter said he trusted he might have the friendly support of the Ordnance Survey. Of that I can assure him. He also says in the report: "It seems possible that the Ordnance Survey Department might combine such work with the maintenance and correction of bench-marks." As to that I am afraid I cannot hold out very great hope. Our Levelling Division, owing to its reduction in numbers, has as much as it can possibly manage to do at the present time. I cannot hold out hope of its undertaking any work which would add materially to its labours. Again, the Levelling Division is always on the move all over the country, and that seems to be likely to militate against supervision of a particular area. However, if Mr. McClean will write to me on the subject and tell me what is in his mind I will be glad to see if I can do anything.

The PRESIDENT: We should be glad if Mr. Sandford-Fawcett would say a few words.

Mr. E. A. SANDFORD-FAWCETT (Ministry of Health): I came here this afternoon not for the purpose of discussing details, because that would be a lengthy business, but at your kind invitation, first of all, to express appreciation of the work that Mr. McClean is doing, and also because I should like to ask for the support of this Society in assisting the Ministry of Health in persuading other institutions and bodies interested in obtaining river gaugings to give the Ministry their help. A good deal of persuasion is required to get work of this kind done—work for which there are no funds available. I hope the members of this Society will be

able to exercise that persuasion. The Ministry of Health is, of course, vitally interested in the question of river-flow, especially from the water-supply point of view. For several years now I have been Chairman of a Departmental Committee of which Mr. Macaulay is a member, and we have been working out a new basis of assessing compensation water. We were not satisfied that the present system was accurate, and our labours have shown that it is not. For the purpose of working out that basis it was necessary for us to obtain as many records of river gaugings as possible, and although I think we have obtained sufficient for our object, we were struck with the lamentable lack of satisfactory river gaugings in the country as a whole.

Of course I am not going to pretend for a moment that I should agree with anybody who said it was a good thing to set up a river organization that was going to gauge every river in the country, because I think it would be a great waste of money. Many rivers are obviously not going to be used in such a way that gaugings are desirable; and also unless you know the purpose for which you are gauging you do not know what point to go to on the river. You may be gauging for the purpose of water supply, in which case you will probably be in the upper waters of the river. You may be gauging, possibly, to see what dilution you can get for sewage effluents, in which case you will be much lower down the river. Gaugings are certainly vital, but it is just as vital to see that they are taken in places where they are likely to be required. Indiscriminate gauging would be waste of money. I hope the Royal Geographical Society will do everything possible to encourage the taking of river gaugings either by voluntary or some other cheap method. I am afraid funds for making gaugings are not forthcoming from the Government. Records of gaugings, when taken, should, I think, be sent to the Ministry of Health, because we have a complete water survey of the country and should like to add all available gaugings to our records.

Mr. F. W. Macaulay (President Institution of Water Engineers): I had intended to say something about, and to elaborate the necessity for, river gaugings of all kinds, but I think sufficient has already been said. Therefore, I should like to add a few words on what appears to me the possible direction any movement towards obtaining river gaugings and river-flow measurements ought to take. For a good many years I was a very strong advocate of it being done by Government, but I have recently abandoned that attitude. The term "recantation" has been applied to me, but I do not accept it. When a general finds that the enemy is very deeply entrenched against frontal attack he is well advised if he tries more indirect methods. The first person who suggested, some years ago, the rainfall organization as a model was my friend Professor Dixon, and for many reasons there is a great deal in it. The rainfall organization, as we all know, was the outcome of the devoted and enthusiastic labours of two great men, Symons and Mill, but it was sixty or seventy years before the value of the work was sufficiently recognized by Government for it to be taken over. I hope we are not going to be sixty or seventy years before we get river and stream gauging recognized. It is obvious that the rainfall organization is a good model to copy, but there is considerable difference and one very vast difference which renders it impossible for stream-flow gauging to follow the model exactly. A rain-gauge is not in itself costly to purchase or expensive to maintain. It only requires a few yards of unencumbered and not too exposed or too sheltered land, and it can be read by anybody with a moderate degree of intelligence. Mr. McClean has indicated the difference there is between that and the cost of river gauging. If one considers direct gauging by means of weirs it is, from many points of view, the most satisfactory, but the initial cost of the weir is great and, as Mr. McClean has indicated, even on a river like the Ness he estimates that something like £300 a

year would be required to get satisfactory measurements. It is obvious that cannot be done by individuals, however enthusiastic they are or however blessed with means. There are only a few who are able to do that. We must look elsewhere.

My friend Professor Stephen Dixon has been for a great number of years doing some very fine work on the Severn, and I think that is a direction in which a beginning, at any rate, might be made, namely through our engineering colleges. The work is done by students who are being trained and who have some degree of intelligence, sufficient to enable them to be of considerable assistance, and of course they would be under the direction of a professor, part of whose job it should be to instruct them in work of that sort. That reduces expense considerably, but still there are expenses which are inevitable and which colleges, like the Government, have not the funds to meet.

I think there must be learned societies and others which have funds which might well be, and would be, very usefully employed in endowing or helping work of this nature. But we have to go further than that. There is a very large number of water authorities of all kinds, water users, who are interested in the use of and who use to a very great extent our rivers. They must be interested and brought into the picture somehow or other. The Ministry of Health has suggested Regional Councils. Those are directed more towards domestic supplies and the allied manufacturing and public services. But the other interests have to be considered, and I personally would rather see the institution of River Boards for each of the principal rivers and for, perhaps, groups of the smaller ones. The Boards should be as highly representative as possible of all the interests on that river. They might have the powers of the existing River Boards, but to them unquestionably should be added the duty of making river-flow measurements where it is obvious that such are going to render a public service. The financing of such Boards would not be a very difficult matter and is not beyond the wit of man to devise. I think perhaps I will leave it at that, but I have tried to give an indication of the direction in which I think efforts should be made to get this most important work going.

Dr. H. R. MILL: When the Research Department of the Royal Geographical Society was organized in the year 1903 one of the purposes to which its activities were directed was that of dealing with the question of the hydrography of the land, river basins, the flow of rivers, and the distribution of rainfall. The function of this Society, of course, is to deal with these problems from the geographical point of view, which differs from the points of view of the Ministry of Health and of the water engineer. Both of these look to applications of natural conditions to special practical ends and we have heard it hinted that it would be waste of time to take observations in places where these practical ends were not immediately in sight. From that argument I must most completely dissent. As geographers we must look on the surface of the Earth as of equal value and importance in all its parts, whether they happen to be put at the moment to human use or not. The thing that we have in mind is, first, to determine the distribution of rain over the varying surface of the land, and that is a subject to which I have devoted the greater part of my working life, because I look upon it as touching the vital nucleus of all geography. Geography as I view it is the study of the surface of the Earth with special reference to the control that land-forms exercise on mobile distributions. Rainfall is the most mobile of all the distributions with which we have to deal, and it is the one which is most completely under the influence of the forms of the land, taken in conjunction with the direction of the wind. The disposal in Nature of the water that falls as rain is equally important and of equal geographical interest. The study of the disposal of water involves the working out of the form of the river bed, its gradient, the shape of its valley, taking account of the gorges

and the wider places and the corresponding rate and volume of the flow. What we want to get at, just as the engineers do, but from a different angle, is the true relation between the amount of rain that falls on the surface and the amount of water that is flowing at any particular point in a river.

The problem, when the whole country is considered, is so difficult and the detailed execution of the researches so elaborate that it is impossible to attempt to deal with more than a very small area at one time. I believe however that a great deal can be done by encouraging individual enthusiasm. I consider that the principal object of the existence of learned societies is not to accumulate masses of statistics and to publish abstruse discussions that nobody is likely to read, but rather to present the problems of Nature in such a form as to arouse the enthusiastic interest of the younger men and women. From enthusiasm has sprung all the great work that has been done in observing rainfall. Symons encouraged enthusiasm from the first; he accepted hundreds of records that he knew to be worthless and carefully put them away in a place where they would do no harm; but he did not discourage the people who took them. He helped them to make better observations, so that after a while many of the bad records became good and, ultimately, valuable.

I am strongly of opinion that much can be done in the way of observing river-flow by encouraging those who live beside rivers to observe the level of the stream at regular intervals and keep a record which might be sent in to the authorities collecting data, to whom should be left the interpretations and discussion. Do not let the individual observer attempt to draw elaborate conclusions from temporary or irregular observations, because they are sure to be wrong, though the observations themselves are quite good. It is easy to devise a river-gauge which will not only show the height of the water at specific hours of the day when it can be noted, but also the highest and lowest levels that the water had reached between two observations. That in the case of mountain streams in particular is very important because they rise and fall so quickly that one might get the same daily reading for a week and yet on every day in that week the water might at some time have been 2 or 3 feet higher and 2 or 3 feet lower than its mean value. This I have seen repeatedly on some of the streams in Wales that have been most carefully observed. To get trustworthy, accurate, and fundamental results continuous automatic records both of rainfall and of stream-flow are required. I only know of one case in this country where such records were carried on for a considerable period; that was on the stream which was dammed to form a reservoir for the Abertillery and District Water Board. There several years' observations were made in order to determine the amount of water that should be left in the stream as compensation after the supply for use had been abstracted by the authority. I am not sure that these records have ever been thoroughly worked up. The report was completed during the war years merely to satisfy the practical requirements, but the records are in existence and should afford an extremely trustworthy guide for constructing such a diagram as that on the screen.

I could say much more, but in justice to other speakers better fitted than I to discuss the paper I conclude by thanking Mr. McClean very heartily for the splendid work he is doing and the extremely interesting series of slides which he has exhibited.

The PRESIDENT: We have with us Mr. Mackenzie who, many years ago, with Dr. Mill and others, undertook for the Society investigations into river discharge.

Mr. N. F. MACKENZIE: I will confine my remarks to the investigation of the River Moriston. The first thing that strikes one is the immediate necessity for establishing a sufficient number of rain-gauges over the catchment area. In his investigation of the rainfall on the Exe basin Dr. Mill will remember that he had

considerable difficulty in arriving at what might be regarded as an average daily rainfall applicable to the whole of the catchment area. On the Exe, which had an area of 450 square miles, I think there were thirty-five rain-gauge stations, though only some twenty were used. Dr. Owens found the same difficulty on the Severn. In an area of 2000 sq. miles there were eighty-three rain-gauge stations available. But the difficulty was really not so much in the number of the rain-gauges as in their unequal distribution, and, working on the analogy of the Exe and the Severn, it seems that we should want some seven or eight gauges for the 150 sq. miles of the Moriston area.

Mr. McClean in his report mentioned the possibility of establishing gauges for water-level purposes on Loch Cluanie and Loch Loyne, and he also mentioned certain proposed rain-gauges. If we take these in order we find that there is one proposed at the pass through the watershed leading down to Loch Duich, and that practically is on the 110-inch isohyet. Then working down-stream there is the existing one at Cluanie Inn on the 100-inch. Between that and the proposed gauge at Ceannacroc Lodge at the junction of the river Doe, which is practically on the 75-inch, there is nothing, either existing or proposed. Then farther down is Torgyle Bridge in a suitable situation, about the 65-inch isohyet. And then we come to Invermoriston, an existing gauge. Outside the area, though sufficiently close to be utilized, I think, are Fort Augustus and Glenquoich.

There is in the report on p. 3 a sentence in which Mr. McClean seems to hint that it is possible to calculate from the rainfall what is the flow of a river. I do not know to what extent it is proposed to utilize that method of arriving at discharge, but a note of warning might be advisable. Dr. Owens went into that subject in his report on the Severn and expressed the opinion that the minimum period for which a useful comparison could be made was twelve months so as to include a complete cycle of the seasons, and even then he pointed out that for twelve-monthly periods on the Severn the discharge expressed as a percentage of the rainfall varied from 42 to 52 per cent., so that even in twelve-monthly periods it is only approximate. If we consider six-monthly periods then the variations become more marked, and if an attempt is made to derive anything from monthly periods I am afraid it is hopeless.

Mr. McClean mentions the loss of 4·4 inch of rainfall out of 11·9 inch in fifty-two days; that is a loss of 37 per cent. in approximately two months. I wish some one would suggest some better term than "loss" for that portion of the rainfall which does not immediately find its way into the river. It is not actually lost, because a certain portion of it finds a way into underground channels and reservoirs and sooner or later some of it appears in the river in the form of springs.

I do not know whether Mr. McClean thinks 37 a high percentage or not, but I might mention that for the months of September and August 1910 on the Exe the loss of the rainfall was 93 per cent. It is perhaps somewhat unfair to select an isolated example such as that, but we might take it for a longer period on the Severn. For the months August and September over a period of eight years the loss was 70 per cent., and on the Exe for the same months during a shorter period the loss was 60 per cent. So that the loss of 37 per cent. is not very much out of the way.

I should like to ask whether on the Garry, on which measurements have gone on for several years, it was found necessary to alter the reduction multiplier when dealing with muddy water. A moderate amount of matter in suspension will cause the specific gravity of river water to increase by something like 10 per cent. So it is quite possible it might be necessary to alter the reduction multiplier.

I noted for the Moriston that it would be useful to mention the intervals, both horizontal and vertical, at which the measurements were taken. Mr. McClean

did mention those for the Garry. I think also it would be useful to give some indication of the method used for interpolating discharges between those actually measured, such as we have in one of the tables for the Moriston. The discharges for gauges for 4 feet up to 10 feet increase regularly by 720 cusecs for each foot of rise of the gauge. Now, there are four variables which come into a calculation of discharge: the area of the cross-section, the coefficient of discharge or of rugosity, the hydraulic radius, and the slope of the water surface. It is a little curious to find that the combination of these four variables should result in an alteration in the discharge directly proportional to the alteration in the gauge reading. It certainly is not impossible, and it does hold true for small ranges of gauge readings, but I have never met a case in which it was applicable for such a range as 4 to 10 feet.

Professor S. M. DIXON (Imperial College of Science): When I returned to this country from America I was interested in the flow of the Severn and I commenced taking measurements there twenty-five years ago, though off and on and only for the purpose of teaching. But since 1921 I have been able to have daily records of the flow of the Severn at Bewdley. It is a good river to measure; the site affords a very good gauging section, and I have now continuous records for nine years. The flow of the Severn is just as irregular as the rain in Great Britain; at Bewdley the variations are sudden and very great. Through the kindness of Mr. Macaulay I have a recording gauge at Severn Bridge, the sheets being changed every week. In twelve hours on 31 May 1924 the river rose 10 feet. We have now had seventy-two discharge measurements spread over the nine years, seventy-one of which were by current meter, the last by floats. We can generally take the measurement by current meter except when the river is very high.

We have fairly good figures for the run-off. In 1921–22 it was 42 per cent. of the rainfall; in 1922–23 it was 51 per cent., and in 1923–24 it was 47 per cent. I think those figures are interesting because that part of the Severn valley is really representative.

My reason for starting the work was, of course, my teaching; it seems to me curious that there should be a province in the Argentine with a River Survey Department where the question is probably not of great importance, while in England, a small country with small rivers easily measured, there is no such department.

Dr. M. A. HOGAN: I would like to know what is the maximum velocity Mr. McClean has measured with the gauging arrangement shown; that is to say, the current meter fixed to the front of a punt. I should have thought that at high velocities it would have been difficult to manage. He said it is proposed to use a recording gauge on the River Moriston. I have had experience of a similar river (the River Liffey outside Dublin) which emphasizes the need for using such a gauge. Professor Purcell and I started taking records in 1922 and fitted a recording gauge. The catchment area is 110 sq. miles, and we found that sometimes the flood rose and fell in about seven hours. It is an exceedingly flashy river, and serious errors might be made in the run-off if a recording gauge were not used.

Dr. J. GLASSPOOLE (Meteorological Office): It is extremely difficult at this stage to add anything useful to the discussion, especially after Dr. Mill's contribution. It was Dr. Mill's personality which first led me to take up the study of the rainfall of the British Isles and, in fact, many of the papers I have published have been the natural outcome of work which originated while he was Director of the British Rainfall Organization.

I feel that in investigations such as that of the Moriston area more useful results could be obtained by some co-operation between those who measure stream-flow and those who have to deal with the rainfall records of this country. It is clear

from a glance at the Cluanie Inn rainfall record that it is not entirely reliable. It is not possible to enumerate here the methods adopted in critically examining returns, but such inconsistencies should be settled with the observer at the time. Further, Mr. McClean, in determining the daily rainfall over the Moriston catchment area has not used the records in that area. He has based the daily rainfall on the record at Glenquoich. Somewhat better estimates could be obtained even in this case where there are only one or two records. As a general rule, it is absolutely essential that maps of rainfall should be prepared on the lines initiated by Dr. Mill and estimates based thereon.

In the footnote to the last table in the report Mr. McClean says: "Inches are given to three places of decimals, as flow can be measured to that degree of accuracy." The largest flow corresponds to 0·638 inch over the area on 17 August, so that the suggestion is that the flow-readings are correct to within 0·2 per cent. That seems to be a much higher degree of accuracy than claimed anywhere else. I should like to join in congratulating Mr. McClean on his work in bringing together this information on run-off and rainfall.

The PRESIDENT: Before asking Mr. McClean to reply I should like to tell him that we have here a record of the Royal Geographical Society's investigation of the discharge of rivers carried out a good many years ago, from which I quote an abstract, namely, that the discharge of the Severn was 60 per cent. of the rainfall in winter and 30 per cent. in summer, on the average. That bears out what Professor Dixon said. In regard to the Exe there was something of the same sort of rule, and in the case of the Medway there was a percentage of 77, though that result was not considered reliable. Now I will call upon Mr. McClean to reply to the points raised.

Mr. W. N. McCLEAN: It is somewhat difficult to reply accurately, at the moment, to all the points raised, so may I later add a written note? I was very grateful to Brigadier Jack for offering the co-operation of the Ordnance Survey, because there are many points which connect water record work with Ordnance Survey. For instance, we could not make some of our levels on the Garry and Oich agree with some of the Ordnance bench-marks. Mr. Sandford Fawcett dealt with what the Government are doing. I hope they will do a little more or give some facilities for getting on with actual records of flow. After all, the cost of getting water-levels in rivers is not big; it only requires a little bit of organization, and that is the beginning of everything. Until we have the water-level records it is not much use measuring very accurately the flows. Mr. Sandford Fawcett also made a point that gauging sections should be chosen according to whether one was measuring for this or that practical reason. I think, in the first instance, you have to choose the point which will give the most information. You cannot measure all the way up the river. On the Moriston, for instance, near Loch Ness I have a point which gives a flow-off from nearly the whole catchment area. If we can get a few more water-level records on the lochs we shall gradually get to know something farther up. But the important thing is to choose the site for measurement at a place which gives the whole flow. When it comes to an engineering scheme which is perhaps only going to use half that area, you still have immensely valuable information. Very few other measurements, perhaps taken at the time, will give you all you want if you have records, right back, of the flow at the principal points of a river.

Mr. Macaulay has kindly come from Birmingham to speak on this subject, and I thank him. As President of the Institution of Water Engineers he is a very important person in the matter of flow of rivers. He is in touch with the Ministry of Health and may be able, as indeed he hints, to persuade them to take a wider view on river-flow records.

Dr. Mill was one of the pioneers in recording rainfall, and it is quite to be hoped that this recording of water-levels will be on similar lines. They do rather go together, and very often the same observer will do both jobs. I have many observers doing that now. On the point whether these observers record quite accurately or not of course Dr. Glasspoole is right: the Cluanie Inn record at present is scarcely worth putting in, perhaps; but, as Dr. Mill said, in another five or six years it may be a different story. Actually 1 inch is recorded in one day for Cluanie, and yet there was no flood whatever in the river! Anybody can tell that is wrong, and in such a case the measurement of flow of rivers is actually helping the records of rainfall.

Mr. Mackenzie raised the question of distribution of rainfall on the Moriston. It is quite impossible for me to put in sufficient rain-gauges at present to record the distribution over the Moriston area. I think that until then it is better to use a good long-record rain-gauge and to compare its rainfall with the flow; especially is this so in the case of the Garry, where Glenquoich Lodge gauge is in a rainy area which provides most of the river-flow. It has a good long record, and I have estimated the distribution on the area as 88 per cent. of that gauge. That, I think, gives a near comparison figure for all time. In the quarterly Reports the inclusion of rainfalls at other gauges will give a fair indication of the variations in distribution which will prove of value.

With regard to the current meter, on one occasion we could not account for a discrepancy in the results, and that was when there was a great deal of vegetable matter coming down after a flood; so that it is really a matter of cutting out those days. Neither the Garry nor the Moriston are muddy rivers at the measurement sites.

The testing of the meters was done in July before the measurements and in October after the measurements. It was rather an anxious moment to know whether there would be the same calibration afterwards as before. There was practically no difference. They were tested in the Froude tank at Teddington and we had to pay the usual commercial fee for getting them calibrated, which all helps to mount up the cost of this work.

Professor Dixon's students took the measurements on the Severn. If one could get students who had completed their course to take up this class of work in this country it would be a great thing. Perhaps after leaving college they want to commence at £300 or £400 a year, and that cannot be done on this sort of work.

With regard to the automatic recording gauges for water-levels, the compressed air gauges are very simple: a little tube goes down into the water as deep as you wish and on the end is an air-box and diaphragm, and records of water-level are made on a clock-driven chart. In a river like the Moriston this is very necessary, because in the matter of an hour that river will have risen over a foot to the summit of the flood and be down again a foot. It is a tremendously flashy river. That, I think, answers all the questions as fully as possible now.

The PRESIDENT: Mr. McClean has introduced an interesting subject and called forth an excellent discussion. I think I should mention that he carried out these investigations entirely at his own expense, and we have reaped the benefit this afternoon. I think it has been shown in the course of the discussion that there is lack of co-ordination and co-operation in this country: information is somewhat scattered and not always easy to get at. What we undoubtedly want is some form of water survey for England, and there is really no reason why we should not have it. If those interested were all to get together I feel sure something could be done, and I feel that the Government departments could help. In fact, we have heard that one department is prepared to help, within reason, and I feel that other Government departments would do the same. It is a matter which ought to be

undertaken, because there are good practical objects in view. I do not see why, as one outcome of this meeting, something of the kind should not be done. There should be some co-operation amongst those interested in the matter, so that there should be systematic work carried out. It should not be left to individuals, like Mr. McClean, who has spent a great deal of time in carrying out work of this kind at his own expense.

I am sure that you will wish me to thank Mr. McClean for his paper and, as a Society, I can safely say that we agree with him that the recording of water-levels at important points on rivers is desirable. I thank him in the name of the Society.

Mr. McClean sends the following note to complete his reply to the discussion:

This Paper now includes a much more detailed account of the Mass-Rate Diagram and its uses than could have been given at the Meeting, and an enlargement has been made for one period in order to illustrate the construction of the diagram. It should be remembered that the rainfall graph is built up from the rainfall distribution adopted in 1913, which was approximately 85 per cent. of Glenquoich rainfall, whereas in the present quarterly Reports on the Garry I am adopting 88 per cent. of Glenquoich for the rainfall distribution in accordance with the mean distribution map provided by the Meteorological Office. The total losses on the three years (1913–1915) would have been about 35 inches instead of 25 inches, or 12 per cent. instead of 9 per cent.; and for the driest six months of each year the losses would have been as follows:

1915	Rainfall	19·47	inches	Loss ..	6·98	inches,	36	per cent.
1913	,, ...	27·62	,,	,, ..	7·65	,,	28	per cent.
1914	,, ...	29·00	,,	,, ..	8·37	,,	29	per cent.

The losses on shorter periods may, of course, reach a higher percentage. On rivers such as the Thames and Severn the comparison of rainfall and flow-off during short periods may yield little information; but on small catchments and on quick run-off areas, such as the Garry and Moriston, the comparison of rain periods with the flow from low river to low river will, I am convinced, yield useful data.

With regard to Mr. Glasspoole's remarks on the Moriston rainfall I have set up two gauges in this area but have adopted a mean annual distribution which originated from the Meteorological Office before those gauges were in action. It will be of great value if the Meteorological Office can review the distribution on the Moriston when improved results arrive from Cluanie. With regard to the Moriston flow-off being given in inches on the area to three places of decimals: On low rivers the water-level can be read easily to $\frac{1}{2}$ inch on the gauge which represents 8 cusecs or 0·002 inch on the area. That is why three places of decimals were in the first Report.

Capt. Withycombe asks for more information as to apparatus and as to cross-sections and particulars of the river-beds. The beds of the Moriston and Garry are of biggish stones and the errors due to bottom irregularities are fairly apparent when the velocities in verticals are plotted and compared. Very much depends on the choosing of the section which may have to be at different sites for high and low rivers. So far as I can judge at present, the best sites are at the lower end of a reach of moderate slope with a swifter river downstream, thereby obtaining something of a sunk weir effect and moderate bottom velocities. The irregular bottom is of course the big difficulty in the measurements of these rivers, but it is possibly a lesser difficulty than the change in beds and slopes of the larger rivers passing through alluvial ground.

The apparatus used and described in the paper is, I believe, the best possible when low cost is essential. Weirs are neither a possibility nor, I think, of value

without the measurement of approach velocities. Light bridges up to 100 feet span would probably be used if measurements became general. On the larger rivers the ropeway with boat or raft seems to be essential. I should like greatly improved water-level recorders, but the cost is too high; in my opinion these water-level records are better kept, not necessarily at the flow-gauging site, but in a rocky reach or pool which is not subject to changes of bed.

This paper has been written, principally, on the records of river-flow and their use. The river Reports are designed to include, quarterly, all the river data of that period. When the survey is complete I hope to describe all the details of the measurements and the working out of the Stage Discharge Curve. But, at any convenient time, I shall be glad to show all the figuring and diagrams and the gauging in progress.

With regard to the future of river gauging I feel with Dr. Mill and others that this is, in the big sense, geographical, and that, consequently, it should be a branch of the Ordnance Survey. The water-level recording and the quarterly Reports are for the River Boards or other water authorities under the supervision of a body which might be 50 per cent. Ordnance Survey and 50 per cent. representative of Science and Engineering and Government.

Lastly, I wish to thank Sir Charles Close and the Royal Geographical Society for their acceptance of my paper and for the very interesting and wide discussion which followed.

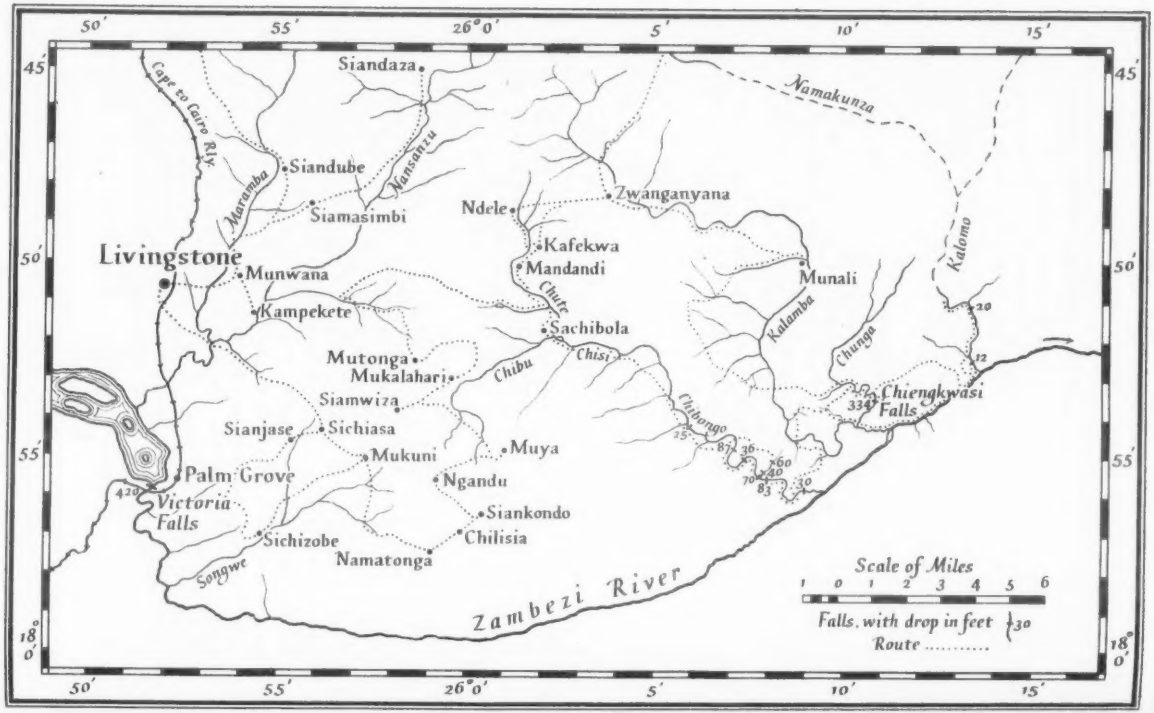
UNRECORDED WATERFALLS IN THE LIVINGSTONE DISTRICT, NORTHERN RHODESIA

FARQUHAR B. MACRAE, Northern Rhodesian Civil Service

ON either side of the Zambezi River below the Victoria Falls there is a considerable area of mountainous country uninhabited and unexplored. On 20 February 1930 I left the village of a headman named Sachibola and, following the Chisi river, which is formed by the junction of the Chibu and the Chute, struck south-east into this area, with the intention of following the river to its junction with the Zambezi and returning by way of the Kalomo river.

To the south-east of Sachibola's village the Chisi enters a deep valley which eventually develops into a gorge running between high mountains and precipitous cliffs. For the first few miles my *ulendo* of carriers followed a terrace in the hillside about 200 feet above the river. Numerous small streams rise in the hills to the west and flow to the Chisi, and there were several springs on the side of the hill above the terrace. We descended to the level of the river at a point about 4 miles from Sachibola's where the Chisi changes its name to the Chibongo, and where there are already signs of the gorge which appears a few miles lower down.

Five and a half miles from Sachibola's there is a small waterfall 25 feet high descending in two drops of about 12 feet each. The river at this point is 90 feet broad. The gorge really starts below this fall. A mile and a half lower down the river is another and more imposing fall, of three distinct drops. The first is a small one of about 6 feet. Fifty yards farther on is a second descending 15 feet,



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but the perennial stream has worn a deep groove in the centre and the water falls with a dull booming sound into a hole, the exit from which is below water-level. At flood time there would be a wide fall here as broad as the river itself. The third drop is one of 54 feet on to a shelf, and a further 12 feet into a deep pool lying across the river, about 120 feet long by 35 feet broad. The fall is divided into two branches by a large rock in the middle of the river. At the edge of the fall the river is 60 feet broad. On the left bank of the river I succeeded in ascending the side of the gorge and descending again to the foot of the falls. The highest point on this side was 225 feet above the lip of the third drop, and the top of the rocks opposite was then on the same level as myself. There is thus on the right side of the river a sheer cliff about 285 feet high, and on the left an exceedingly steep hillside of almost equal altitude. The river below the falls is 80 feet broad. Below this fall the gorge becomes deeper and deeper the farther one proceeds. The hills become steeper, cliffs more numerous, and vegetation more and more sparse. The bed of the river is composed of large surfaces of bare rock, and rapids and cascades alternate with big pools of still water.

A mile below the second fall is a third fall of 15 feet, a chute of 12 feet at an angle of about 45° and, 100 yards lower down, a similar chute of 9 feet. After a space of another mile there is a fourth fall where the river drops into a deep hollow formed by the confluence of several mountain torrents and surrounded on all sides by high hills. The fall begins with a cascade and two chutes at an angle of about 15°. The height of these is about 30 feet. Immediately below is a drop of 400 feet into a large pool about 100 feet in diameter. The total height is therefore 70 feet. On the left bank a small tributary joins the main river after a fall of about 60 feet, a series of cascades for about 100 feet, and a second fall of about 40 feet. The river flows out of the large pool just mentioned in a series of rapids, and 200 yards farther down falls 83 feet in two drops of 8 feet and 75 feet into an exceedingly deep gorge. This fall is in two branches and the river at the lip is 60 feet broad.

Below this fall the scenery is most imposing. Towering basalt precipices rise on either side of the river, which is never much more than 100 feet broad and is generally considerably narrower. At one point the cliffs cannot well be less than 400 feet high and are probably higher. They rise in one sheer wall from the water's edge. The general impression of height is greater than that conveyed to an observer standing at the bottom of the Palm Grove at the Victoria Falls. A mile and a half farther down there is a fifth fall of 30 feet, the river being here about 50 feet broad. This fall is within a mile of the confluence with the Zambezi.

From this point I struck across country, crossed the Kalamba river, and camped a short distance from the Chunga, a small stream running between low banks in undulating country. After following this river for a distance of about a mile I came to a large waterfall known to the natives who live to the north as Chiengkwasi. This is a series of falls, 12, 25, 20, and 200 feet, followed by four smaller totalling 50. Between the first and second drops is a space of about 100 yards, but all the others follow after each other in quick succession.

I visited this fall on two occasions and made a number of observations with a small aneroid barometer. I determined the height from the foot of the lowest

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cataract to the lip of the highest cataract to be 334 feet. I measured the height of the main fall of 200 feet by the same means. The gorge below this fall is narrow and very deep, with precipitous cliffs and steep hills on both sides. I estimated the depth at 400 feet. At the top of the main fall the Chunga River is 60 feet broad.

The main Chiengkwasi fall is a fine sight. Numerous very green ferns grow in holes and cracks in the stone and the water dashes down over the smooth face of the rock, spurting out in little plumes of spray wherever it meets an obstacle. In times of flood it must be an awe-inspiring sight during the few hours that such a short river would remain at its maximum height.

After leaving my camp near the Chiengkwasi Falls I descended by a small stream, falling in a series of cascades about 300 feet in the space of half a mile, to the Kalamba river, which I followed to its confluence with the Zambezi. I then followed the Zambezi for $3\frac{1}{2}$ miles to the Kalomo river confluence. I followed the Kalomo a further $3\frac{1}{2}$ miles from this point, having told two men to come across country to meet me at the Kalomo river. Owing to the difficult nature of the country, however, they failed to reach the Kalomo, and I was obliged to spend the night on a hillside, having made an unsuccessful attempt, as night was falling, to find a way out of the gorge.

The Kalomo river is 190 feet broad at its confluence with the Zambezi, and the Zambezi in its normal bed is 150 yards across. Wherever I saw the Zambezi it was running very fast, and there were numerous formidable rapids. The hills on either side rise abruptly for about 500 feet. At the Kalomo confluence the Zambezi appears in times of flood to reach a width of about 400 yards. It was here exceptionally wide. I found two falls on the Kalomo, the one nearer its mouth 12 feet high and the second 20 feet. Three and a half miles from the Kalomo–Zambezi confluence my progress was stopped by the narrowing of the gorge to a rift which appeared to be about 200 feet deep and not more than 60 feet wide at the top. The bottom was apparently only some 20 feet broad, and the whole space was occupied by the river. The men who were with me, asked later to give their impressions of this rift, said that it was considerably narrower than 60 feet at the top. One man indicated a distance of 20 feet, but I think that he was considerably out in his estimate. At the same time there were trees on the skyline of the usual acacia type, and it appeared that if one of them had been cut down it would easily have reached from side to side. How far back this rift continued I am unable to say, as it was then late, the light was failing, and everything inside was dark and gloomy. Having spent the night near this place I succeeded in finding my carriers again the next morning. I did not return to the rift, firstly because I was then without food and I was not certain where my camp was, or how long I should take to find it, and secondly because my men were running short of food and it was imperative that I should return to an inhabited part of the country where I could obtain a fresh supply.

On the sixth day after leaving Sachibola's village I returned to Munali's village, following more or less the valley of the Kalamba river, which I crossed a second time about 2 miles above the point where I had first seen it two days before. Aneroid readings taken at the two spots and at about the same time in the morning made the difference in height 700 feet. This is not, of course, a

The Chibongo river just above the gorge

The first fall on the Chibongo

The second fall

UNIV. OF MICH.

The main Chiengkwasi fall

The fourth fall on the Chibongo

reliable figure as there was no means of knowing what were the daily variations of atmospheric pressure, but it is a figure which fits in with the general conformation of the country. The fall in the level of the river below where I first crossed it is small in comparison, and I do not believe there is any waterfall of any size in the short portion which I did not explore. Above the place where I first crossed it there is, comparatively speaking, no very considerable gorge. At this point I obtained a view upstream and was unable to see, with field glasses, any cliffs indicative of a considerable cataract or anything in the bed of the river larger than the usual rapids. My opinion is that the Kalamba descends rapidly in a series of cascades and not in a large fall. This however remains to be shown.

My measurements of breadth were made with a box sextant and are given in round numbers. Where only an approximate breadth is given the measurement is an estimate by eye. The same applies to heights, but where a definite figure is stated this has been arrived at by direct measurement, by estimate with a small aneroid barometer, or, in the case of small cataracts, by placing a man of known height against the foot of the fall and estimating with a pencil held at arm's length in the manner followed by artists when copying figures. The accompanying sketch-map I have compiled from a prismatic compass traverse, various field notes, and sketches, and information obtained from natives who had some knowledge of the district. At later stages, not shown, it was checked against known fixed points, and I believe that as a result it is reasonably accurate.

Several of the falls here described were unknown even to natives who were acquainted with the area, and, so far as I can ascertain, I am the first European who has visited this part of the country.

The fourth fall on the Chibongo

The main Chiengkwasi fall

THE DEATH OF MR. A. F. R. WOLLASTON

A GREAT loss has fallen upon the Society by the tragic death of its Honorary Secretary, Mr. Alexander Frederick Richmond Wollaston, Fellow and Tutor of King's College, Cambridge. He was present at our Council on June 2. In the early afternoon of June 3 he was shot through the heart in his College rooms by a scholar of the College who afterwards committed suicide. By this crime the Society is robbed of an Officer whose great and various talents had for many years been devoted unsparingly to its interests.

At the Funeral Service in King's Chapel on the afternoon of June 7 the Society was represented by Col. Sir Charles Close, President; Admiral Sir William Goodenough, President Designate; Brigadier Jack, Hon. Secretary; Dr. T. G. Longstaff, Hon. Sec. Designate; the Reverend Walter Weston; and the Secretary.

Before the paper read at the Evening Meeting on Monday, June 16, the PRESIDENT (Colonel Sir CHARLES CLOSE) said: We have all been deeply moved by the news of the lamentably tragic death of our Honorary Secretary, Mr. A. F. R. Wollaston, whose kindly, valuable, and well-spent life was, two weeks ago, brutally cut short. It is thought that before we proceed further with the normal business of this meeting it will be the wish of all present to listen to some of those who were our dead colleague's companions in his various journeys. We have one or two letters from those who travelled with him, and we have with us Colonel Howard-Bury, who was in charge of the Mount Everest Expedition of which Mr. Wollaston was a very remarkable and prominent member. I will ask the Secretary to read some of the letters which he has received, and I will then call on Colonel Howard-Bury.

Mr. HINKS: At your behest, Sir, I have tried to get to the meeting this evening some of those who had been with Mr. Wollaston in his three great enterprises. The first was the expedition to Mount Ruwenzori in 1906 on behalf of the British Museum, of which Mr. Douglas Carruthers is now the only survivor. Mr. Carruthers wrote that he fully understood the Council's desire to commemorate the memory of Mr. Wollaston, but for himself he felt so deeply the terrible murder of his greatest friend that he could not yet speak about it in his own family, much less could he bring himself to address the meeting to-night. He felt sure that the President and the meeting would feel with him in that respect.

Mr. Wollaston's second great enterprise was in the exploration of New Guinea, and it has not been possible to find in England any one of his comrades on the two expeditions. One is in Bolivia; one is somewhere in West Africa; and one is in Singapore, so that no one can speak to-night from personal experience of Mr. Wollaston's work on those journeys.

Then there came the war; and General Sir Horace Smith-Dorrien, whom you invited to be here to-night, writes regretting that it is impossible for him to come as he must be in France to-morrow. He says, "Your letter gave me the first intimation that the victim of the terrible tragedy in Cambridge on the 3rd instant was the attractive man who was for a short time Medical Officer on

my Staff in 1915–16." Going on to speak of his misfortune in being taken seriously ill on the voyage out to Africa he says, "When it was realized that I was far too ill to be able to exercise the command to which I had been appointed, Wollaston had to leave me and proceed to Mombasa to join the Forces. I heard often how much he was beloved by all he came in contact with in the East Africa Expeditionary Force." Others have spoken of the reputation that Dr. Wollaston made afterwards in the Murmansk Force.

To those letters Sir Francis Younghusband asked that this might be added: He regretted that he was unable to be present but wished to add one word to the tributes which he knew would be paid to Wollaston. Sir Francis said: "He was of the very best stuff that explorers are made of; the staunchest companion and a lover of every living thing. Every one must regret his loss and be grateful for what he did for our Society."

Colonel HOWARD-BURY, M.P.: I should like to pay a few words of tribute to the memory of Alexander Frederick Richmond Wollaston. He was with me during the first Mount Everest Expedition and we were closely associated. The dark shadow of this tragedy has fallen not only over the College with which in the last few years of his life Mr. Wollaston was closely associated, but also on all those who took part with him in geographical exploration. From the many tributes that have been paid to him by undergraduates with whom he worked during the past few years of his life there emerges this salient feature, that he was accessible to every one; that nothing was too small or too trivial for him to give his deepest attention to; and in addition he had a wide wisdom, acquired in expeditions in distant lands, which he was ready to dispense to any one who came to him for advice or consultation. We all of us remarked upon that feature of his life. Nothing was too much trouble for him, and when we had cases of sickness or enteric among our porters or camp followers no one could have taken more trouble than did Wollaston in his endeavours to cure them and to bring them back to health.

Throughout the first Mount Everest Expedition in 1921 I was perhaps more closely associated with him than with any other member of the expedition. He was not only Medical Officer but he was also botanist and naturalist; and with all that he was a brilliant photographer, many of the finest photographs brought back from that expedition being due to Wollaston's great skill. He was my companion possibly more often than any other in the different trips that we made, for we had many tastes in common. He loved birds and flowers and had an intense appreciation of all that wonderful scenery that was unrolled before us day by day. I remember telling him of the first visit that I paid to the Karma Valley, a valley of incomparable beauty. He was so fired with a desire to see it that we were happy and lucky to make two expeditions together into that valley, and I watched his intense enjoyment of every little thing in it; nothing was too small to attract his attention. The beauty of the flowers, the beauty of the mountains, of the scenery—all were intensely appreciated by him. Wollaston was, if I might say so, a most ideal companion, and only those who have travelled much know how difficult it is to find the real companion with whom one can share all one's difficulties and all one's troubles month after month. He seemed to fit in anywhere and everywhere and, in addition to that accomplishment, he had a wide wisdom of the ways of man in the world. He was an ardent lover

of the countryside and passionately devoted to the study of animal and bird life and to the study of flowers and trees. Besides that, he had a joyous sympathy with people of every race and every class which enabled him to get on so well with every one with whom he came into contact.

Wollaston was the first European to visit the sacred temple of Lapchi, the home of that great poet and saint Mila Respa, who lived and who died and is buried there, and about whom Wollaston wrote so feelingly. I remember that from that expedition he brought back a most beautiful primula which has been named after him. His description of that primula was that "Every bell of it was as large as a lady's thimble, of a deep azure blue and lined inside with frosted silver." That remains to us a joy for ever, but we, alas, to-day mourn his loss.

Recently in my Irish home, when looking round the shrubs and trees he and I had together collected as seeds many years ago, I thought much of him and mourned his loss deeply. We have said good-bye to him in this life, but he has left behind him the memory among us all of a true friend, an ideal companion and an ardent lover of the mountains.

The PRESIDENT: The Council to-day decided to send a message of sympathy to Mrs. Wollaston, and I feel sure that all present will associate themselves with the message by standing while I read it:

> We, The President and Council of the Royal Geographical Society, tender to Mrs. Wollaston our profound sympathy in the tragic death of her husband, our well-loved colleague and friend. The country has been robbed of a distinguished geographer and explorer, and our Society of a Fellow whose valued services were marked by the award of our highest honour and by election to important office. We deplore the grievous loss which since our last meeting has befallen his widow and children, his College, and our Society.

THE BRITISH ARCTIC AIR ROUTE EXPEDITION

THE most promising air route from England to Winnipeg and British Columbia is by way of the Faroe Islands, Greenland, Baffin Land, and Hudson Bay, because the longest sea crossing is only about 320 miles between the Faroes and Iceland. But the route crosses the least-known part of Greenland: the coast-line for 200 miles north of Angmagsalik nearly to Scoresby Sound being almost entirely unsurveyed and the interior entirely unknown. The main purpose of the expedition, which has been organized by Mr. H. G. Watkins, is to complete the survey of this coast, to explore the interior, looking especially for high mountains, and to study the meteorological conditions both of the coast and the interior ice-cap over a period of at least a year. Under the Honorary Presidency of H.R.H. the Prince of Wales and the Chairmanship of Major Stephen Courtauld a small committee was formed to raise the necessary funds and equip the expedition: the other members being Mr. Andrew Holt, Mr. J. M. Wordie, Mr. H. G. Watkins, and Mr. Augustine Courtauld, with Captain Ralph Rayner of the Royal Corps of Signals as Honorary Secretary and the member especially charged with the necessary liaison with the Canadian authorities. Certain members of the Committee and other benefactors have generously financed the expedition, to which this Society has been able to give a grant of £300 from the Expedition Fund and to lend many instruments. Several departments of His Majesty's Government have contributed very materially to the expedition by lending the services of an air pilot, a wireless officer, and a medical officer, as well as by the loan of equipment. The expedition has chartered the *Quest* to take them to the east coast of Greenland with two de Havilland Moth seaplanes fitted with interchangeable ski undercarriages. They have two motor boats and fifty sledge dogs.

The main base of the expedition will be near the Eskimo settlement of Angmagsalik, where a Meteorological Station will be maintained throughout the whole fourteen or fifteen months during which the expedition will be in the field. It is the intention to establish a second station 140 miles inland on the ice-cap, and to relieve the observers at that station each month by dog team. It is intended that several long sledge journeys on the ice-cap should be taken to determine its height and the boundaries of the mountainous area. Meanwhile the coast-line will be surveyed as far as possible by ship and the detail completed by air photography. At some time during the year they hope to make a flight over the ice-cap to Disko Island, and at the end of the winter Messrs. Vickers (Aviation) Limited propose to send a "Vellore" aeroplane for an experimental flight along the route determined by the work of the expedition. It is expected that the *Quest* will sail from the Thames on July 3 or 4 with the following strong personnel: H. G. Watkins, Leader; A. Courtauld, Surveyor; J. Scott, Surveyor and Dog Driver; Flight-Lieut. D'Aeth, Pilot and Meteorologist; Capt. P. Lemon, Royal Signals, Wireless Officer; Surg.-Lieut. Bingham, R.N., Medical Officer; L. R. Wager, B.SC., Geologist; A. Stephenson, Chief Surveyor; J. Rymill, Surveyor; F. S. Chapman, Surveyor and Ski Expert; Q. Riley, Meteorologist; W. E. Hampton, Engineer; Lieut. M. Lindsay, Royal Scots Fusiliers, Surveyor.

It is the most ambitious expedition to the Arctic which has been fitted out

from this country for many years, and the party will take with them the most earnest wishes of our Society for the complete success of their important project. When the plans were first laid before the President and Council they gave the proposal their hearty support and recommendation. They highly appreciate the public spirit and generosity of the benefactors who have made the expedition possible by providing the large and necessary funds; and the thanks of all are due to the Royal Government of Denmark, who have accorded every facility to the enterprise.

TECHNIQUE OF AIR SURVEY

PROFESSIONAL PAPERS OF THE AIR SURVEY COMMITTEE

No. 5. CALIBRATION OF SURVEYING CAMERAS. By Captain M. HOTINE, R.E. 10×6 *inches;* 81 *pages; and illustrations.* 2*s* 6*d*

No. 6. EXTENSIONS OF THE "ARUNDEL" METHOD. (A continuation of Professional Paper No. 3.) By Captain M. HOTINE, R.E. 10×6 *inches;* 116 *pages; illustrations and maps.* 4*s*

London: H.M. Stationery Office, 1929.

IN order that the detail appearing on photographs may be plotted correctly on a map it is essential that the principal point and the principal distance of the photographs shall be accurately determined. The measurements defining the principal point and principal distance are functions of the camera that has been used. The determination of these measurements is called the "calibration" of the camera. The calibration can best be done in a physical laboratory, but any change in the condition of the camera may produce changes in the measurements. It is therefore necessary that each camera should be calibrated in the field before it is used.

For field calibration the camera is set up, and levelled, and a photograph, on a glass plate, is taken of sharply defined and distant objects which are at about the same level as the camera. The camera is then turned on its side, and a second plate exposed. The angles subtended by these objects at the camera station are afterwards measured with a theodolite, and the vertical angles to them are also observed.

One object which is at or near the centre of the photograph, and two others in the right and left marginal fields, and which are about equidistant from the centre, are selected, and their positions on the photographic plate measured in a coordinate measuring machine—the tip of the image of one collimating mark being taken as the origin. These measurements, and the angles observed with the theodolite, provide sufficient data for the computation of the principal distance, and the coordinates of the principal point. The fixation of the principal point may however be in error by $\frac{1}{4}$ mm. It is better, therefore, to take three points near the centre of the photograph, in addition to the two in the marginal field, and to solve the resulting observation equations by the method of least squares. Since two photographs are taken—one with the camera in its normal position and one with the camera on its side—two determinations of the principal point and principal distance can be made. These check each other, and should not differ appreciably.

When the principal point has been determined, a template is prepared for the

camera. By the aid of the template the position of the principal point may be pricked through on the photographs.

There are several methods of calibrating cameras in a laboratory. These methods are of two classes. The first involves the measurement of angles only, and the second the measurement of distances only. Two methods of the first class are described: (*a*) the direct measurement of perspective angles. In this method the camera is placed on a revolving table, which may be turned through a measured angle; the observations being made through a fixed telescope. (*b*) Fourcade's method, in which both the viewing telescope and the camera are fixed, but the rays from different parts of the camera plate are reflected into the telescope by a movable pentagonal prism. Baker's method belongs to the second class, and involves the measurement of the distances of the images of a collimator wire on a photographic plate. The images are moved through a known perspective angle—by means of multiple reflection from a set of prisms—before each exposure.

A short chapter is devoted to the calibration of double cameras. These may be calibrated by photographing the positions of nautical almanac stars, or by the use of Fourcade's Stereogoniometer, a description of which is given.

The "Arundel" method of plotting from air photographs—described in Professional Paper No. 3—is based on the assumption that the angles formed by rays drawn from the principal point to other points on an air photograph are the true horizontal angles. Provided the country is moderately flat, and the camera not much tilted, this assumption does not introduce any serious errors in plotting maps on topographical scales. In order that the method may be carried out, the photographs should have an overlap of more than 50 per cent., so that every photograph in a strip will contain the principal point of the preceding and following photographs. It is then possible to orient the photographs correctly, and to plot the principal points and important points of detail of the whole strip, by the intersection of rays from the principal points. If distortion has been introduced by differences of ground relief, or camera tilt, a small triangle of error will be formed by rays which should pass through the principal point of the photograph. The true position of the principal point lies within the triangle of error, and can be located by eye. This method of plotting was first applied to the air photographs of an area near Arundel, and has since been used with success in the plotting of air surveys of Hongkong, Malta, and Gozo.

In the "Arundel" method contours are drawn on the photographs with the aid of a topographical stereoscope, fitted with parallactic grids. The height of any point which appears on a photograph may be measured in the stereoscope, by observing the parallax difference between that point and a point of which the true height is already known. This method therefore presupposes that the true heights of a considerable number of points have already been determined on the ground.

A test survey was next carried out in the "Glen Clova" district of Angus. As the country was very hilly, the assumption that correct angles were formed by rays drawn from the principal points of an air photograph to points of detail no longer held good. It became essential to substitute, for the principal point, the plumb point of each photograph. To determine the position of the plumb point it was necessary to compute the relative and absolute tilt of each photograph of a strip. The relative tilts were determined by computations based on the errors of correspondence between the images of well-defined points which appeared on two adjacent photographs. These errors may be easily measured in a precise topographical stereoscope. As this instrument was not available for the Glen Clova survey a coordinate measuring machine was used. The absolute tilt of each strip was computed from four spot heights at each end of the strip. After the

plumb point of each photograph had been fixed in this way it was possible to plot the whole strip by the "Arundel" method.

The contouring of the photographs was also carried out by the "Arundel" method, but on steep slopes the parallax difference between points at the top and bottom of the slope may exceed the grid interval of the stereoscope. In such cases, before the contours can be drawn, it is necessary to interpolate, by the use of the stereoscope, a sufficient number of heights on the slope to reduce the parallax difference between any two points to less than half the grid interval.

It is estimated that a skilled operator can plot and contour 2 square miles per hour, on photographs on a scale of 1/20,000, by the simple "Arundel" method. When a preliminary strip analysis must be made, as in the Glen Clova survey, his output is reduced by half. It is claimed that by these methods excellent topographical maps may be produced on scales between 1 inch and 6 inches to the mile. The accuracy of the final map will depend largely upon the density of ground control, that is, upon the number of triangulated points and spot-heights in the area.

Paper No. 6 also contains a chapter on Reconnaissance Surveys, and a description of the Barr and Stroud Epidiascope. This instrument is particularly suitable for the revision of large-scale maps. An image of the air photograph can be thrown upon a transparent tracing, or print, of the existing map in such a way that, provided the country is flat, exact correspondence is obtained between the two. A draughtsman can then draw the new detail from the air photograph in its correct position on the transparency of the existing map. It has been found that, with a little expert manipulation, the instrument can deal with flattish country, or with uniform slopes that do not exceed 15°.

As the Air Survey Committee are evidently satisfied that the preparation of topographical maps from air photographs has now passed the experimental stage, it is to be hoped that they will now publish a text-book on the subject, for the guidance of surveyors, draughtsmen, and instrument makers. The Professional Papers already published contain the gist of the matter, but it is scattered amongst six separate publications, and the reader must be in possession of the complete set before he can follow the arguments or instructions. Until the essential matter has been collected into a single book, arranged in its logical order, and indexed, it will not receive the attention it deserves. J. E. E. C

REVIEWS

HANDBOOK OF THE GEOLOGY OF GREAT BRITAIN: A Compilative Work. Edited by J. W. EVANS and C. J. STUBBLEFIELD. *London: Thomas Murby & Co.* 1929. 10×7 *inches;* xii+556 *pages; maps and diagrams.* 24*s*

This well-produced book is a new and extended edition of the volume dealing with the British Isles which appeared some twelve years ago in Heidelberg as one of the series of the 'Handbuch der Regionalen Geologie,' which was issued under the general editorship of Professor G. Steinmann and Professor O. Wilckens. Written in 1913, the proofs were in the hands of the English contributors in August 1914, and despite the difficulties caused by the war, the book was eventually published in Germany in 1917. For long the original edition proved difficult to obtain in this country. The copyright has since been purchased and Thomas Murby & Co. are to be congratulated on securing the work for publication. A large part has been rewritten, a number of new contributors appear, and Dr. Stubblefield is now associated with Dr. Evans as the general editor.

The book automatically takes its place as a standard work on the stratigraphical geography of Great Britain, the corresponding volume on Ireland by the late Prof. G. A. J. Cole and Mr. T. Halissy having been issued in 1924. There is a brief and valuable introduction on the morphology of Great Britain, that part dealing with England and Wales by Prof. Morley Davies, and that dealing with Scotland by Prof. J. W. Gregory. This section is accompanied by a useful tectonic map. Then follows a very brief section on the earthquakes of Great Britain by Dr. Charles Davison, and the remainder of the volume is concerned with stratigraphy.

It is in accordance with the tradition of the older school of British geologists that 300 pages should be devoted to the Palaezoic rocks, compared with only 150 for all the Mesozoic and Kainozoic strata which bulk so largely in the whole of the south-east of England. It follows, as indeed is inevitable in a compilation, that there is a certain inequality between the sections. Some are extraordinarily complete, notably that of Prof. Garwood on the Lower Carboniferous, which is a very important contribution to the knowledge of the subject and in addition contains a very complete bibliography. It is natural that one should turn in such a volume to the treatment of the great disputed questions of geology at the present time. Prof. O. T. Jones in his extremely able description of the Silurian strata gives a very fair and clear explanation of opposing views. It is interesting to notice that he favours the return to the classification of Silurian into Llandoverian, Wenlockian and Ludlovian, thus dropping the term Salopian which was introduced after Murchison's original classification. He also summarizes very clearly the work which has been done in recent years on that group of rocks which is usually called the Downtonian, and he accepts the Ludlow Bone-bed as the base of the group. Perhaps the most disappointing section of the whole book is that on the Devonian, by the senior editor. Dr. Evans has little to add to his account of seventeen years ago, and actually obscures the general issue by ignoring entirely the careful preceding exposition of Prof. Jones. To Prof. Morley Davies has fallen the writing of the most difficult chapter in the whole work—that on the Jurassic. He accepts the basis of S. S. Buckman's work that "unequal denudation of very gently folded strata can alone explain the limited distribution of ammonite faunules," but he refers the reader to the original works of Buckman instead of attempting to summarize his work. Indeed, he has taken the somewhat extraordinary course of drawing up his correlation tables by selecting certain hemerae only for inclusion, and ignoring, without

reason, the others which Buckman has recognized. He says that the hemerae selected are those which are most widely represented by deposits, or which are represented by deposits of special importance for some reason or another. Prof. Boswell, in his section on the Cretaceous, follows the more logical plan of giving the modern ammonite sub-zones or hemerae laid down by L. F. Spath, and then describing the rocks entirely according to their old lithological position. Prof. Boswell also contributes the section on the Tertiary rocks; in the brief space allotted to him he has introduced the main results of recent work, and the section is thus very different from that which appeared in the first edition.

The difficult question of the glaciation of Great Britain is ably handled by Dr. Slater. In the Appendix Dr. Plymen deals with the geology of the Channel Islands, rather studiously ignoring the views of other workers which are often widely divergent from his own. L. D. S.

ANCIENT EMIGRANTS: a History of the Norse Settlements of Scotland. By A. W. BRØGGER. *Oxford: Clarendon Press* 1929. 9×6 *inches;* xii+208 *pages; illustrations and maps.* 15*s*.

These Rhind Lectures give a famous scholar's interpretation of many features, past and present, of the life of the Orkneys and Shetlands and other regions, including the Hebrides, over which Norse emigrants spread in the eighth and ninth centuries of our era. The author himself came across the North Sea in a small sailing yacht, and this is but one instance among many that show how closely and concretely he followed the problem out. One could wish that he had felt able to look back into the Bronze Age rather more fully, because the distribution of finds and monuments gives hints of active maritime intercourse in those days and of links between Scotland and Denmark. The way down the Minch is marked by hoards of bronze swords here and there, and the Brochs belong to the sides of the Minch, the Orkneys and Shetlands. Brøgger thinks they date from Pictish days, or about 300 B.C. onwards. In their day still Orkney had forests and forest animals, as Childe has recently demonstrated afresh. Afterwards however a cool damp phase of climate appears to have taken effect by destroying the forests, and thus making maritime activities almost impossible; this reduced the population of the Orkneys and Shetlands until prosperity returned to the north with, if Pettersson is right, a renewed climatic optimum, as well as the spread of the working of iron ores in Norway. One of Brøgger's main theses is that the Norse emigration to Orkney and Shetland of the eighth and ninth centuries A.D. was an expansion of a prosperous people. In a time of expansion the poorest farms would be left by families lured on to new opportunities overseas, as movements of the nineteenth century show so well. In the Norse case also the Odel system of land tenure would promote emigration by limiting the break up or sale of farms, the kin having the right to buy in. By means of place-name studies Brøgger is able to trace back the settlers in the isles to the various provinces of Norway, and to show what a large part Møre had in the exodus of peasants. Apparently a later phase of the emigration was connected with the resistance of local princes in Norway to the organizing activities of Harold the Fairhaired; these later movements appear to have specially affected the Sudreys or Hebrides.

Of the almost stealthy way in which the Church, and with it Scottish influences, crept first into Orkney, and then ultimately into Shetland, Brøgger gives a very vital account, and he ends up with a sketch of the economic changes of the fifteenth century, including the rise of the North Sea herring fishery and the extension of this activity to fishing in northern seas from Scotland and the Isles, the while Norway slipped back into poverty and weakness. The reader who follows the well-built argument will gain from this book much insight into

problems of demography and social organization, and will feel that here is an interpretation of much that was hitherto fragmentary in our knowledge of what may now be called Norse Scotland. H. J. F.

ACROSS ICELAND. By OLIVE MURRAY CHAPMAN. *London: John Lane* 1930. 9×6 *inches;* xiv+193 *pages; eight illustrations in colour and forty-six in black and white; sketch-map.* 15*s*

This new book of travel in Iceland was certainly overdue; we cannot remember to have seen anything of the kind in English since W. Bisiker's volume with the same title appeared in 1902. It has come at an opportune moment when the attention of the world has been attracted to the island by the festivities celebrating the millenary of the Althing. Intending visitors to Thingvellir this June were able to forearm themselves with this informative book, and many, no doubt, had their eyes opened, not so much by the descriptions of the scenery which fulfils all expectations of severity and ruggedness, as by the chapter on modern Icelandic art and the photographs of Einar Jónsson's vigorous sculpture. It is sad that this high degree of civilization has not been reached without such accompanying drawbacks as motor lorries and other discordant modernities. We are told that the attractive native ponies which figure in many of the photographs will patiently face any fatigue and danger but become quite unmanageable at the sight and sound (not to mention scent) of a motor-car. Roads (of a sort) are rapidly being extended and rivers are gradually being bridged, so that it appears possible to travel by car now, with occasional breakdowns, from Reykjavík most of the way to Akureyri. An adventurous ride, such as the author took from one hospitable farmhouse or parsonage to another, will soon have to be directed through the bleak wastes of the interior, with the necessity of carrying camping outfit and forage, or to such uncomfortable localities as the solfataras of Námaskard, where the greatest care has to be exercised to avoid being swallowed up in hot bogs. The picture of this weird scenery is one of the most successful of the author's drawings; many of her photographs, especially those of the Thórsmörk mountains, are very striking. We suggest that she is mistaken in naming the water-filled rift at Thingvellir (reputed to be the scene of Flosi's leap) the Hrafnagjá, which is a much wider and boulder-strewn chasm on the far side of the plain corresponding to (but 3 miles distant from) the famous Almannagjá, the scene of this year's ceremonies. J. H. R.

A WAYFARER IN BAVARIA. By SUZANNE ST. BARBE BAKER. *London: Methuen & Co.* 1930. 8×5 *inches;* x+218 *pages; illustrations and map.* 7*s* 6*d*

It was a happy thought to publish 'A Wayfarer in Bavaria' this year, as the Oberammergau Passion Play is being given, and many who visit there must wish to know more of the charming and romantic country through which they pass. Mrs. Baker has done her work well. In parts the book reads a little too much like a catalogue, occasionally there is a looseness of phrase, and one might expect at least a reference to such places as Bamberg and Kissingen; but, apart from these small blemishes, the volume is excellent. It begins appropriately with a summary of Bavarian history; then the larger towns are described; afterwards we are taken to the lakes and mountains. There are brief, well-written accounts of the Passion Play and Bayreuth, and the notes on the wonderful palaces of Ludwig II are quite accurate. Perhaps the best chapter is that on Rothenburg. As usual in this series the illustrations are remarkably clear and good. A. W. S.

DIE OSTALPEN UND DAS HEUTIGE ÖSTERREICH. By Dr. NORBERT KREBS. 2 vols. (2nd edition). *Stuttgart: J. Engelhorns Nachf.* 1928. 9×6 *inches;* xiv+330, x+496 *pages; illustrations and maps. M.*48

The second edition of this standard work by the Professor of Geography in the University of Berlin will be welcomed by all geographers. Originally destined to be a Geography of Austria-Hungary in pre-war days, it has been rearranged in accordance with the post-war distribution of states.

It is impossible to summarize the book in a few words, for it is worthy of deep and prolonged study. Special attention is given to land-forms in the light of the latest research. The illustrations are beautiful and well chosen. There are many maps and sketches. The first volume gives a general description of the formation of the Alps; of the Ice Age and its influence; of the climate of the Eastern Alps; of the peoples and their complicated relationships; and of the general economic conditions. The second is a series of regional studies, finishing with a short but illuminating account of Austria as she is to-day, an Alpine remnant, with her huge capital, Vienna, situated in a far corner. There is a full bibliography; a list of authors for reference; and an index.

The two volumes are indispensable to any one who wishes to make a serious study of Austria and the Eastern Alps. A. B.

EXPLORATIONS IN CENTRAL ANATOLIA. Season of 1926. By H. H. VON DER OSTEN. (Univ. of Chicago Oriental Inst. Publ. Vol. V. Researches in Anatolia, Vol. 1.) *Chicago: University of Chicago Press (Cambridge: University Press)* 1929. 12×9 *inches;* xx+168 *pages; illustrations, maps, and plans.* 18*s*

This publication of the Oriental Institute of Chicago University gives an account of a journey, made in 1926, by motor car from Mudania to Angora, and thence to a number of sites within the great bend of the Halys River, the most important region of the Hittite Empire. In this rapid survey the author visited places where Hittite remains have been found, notably Huyuk and Boghaz Koi, and noted the sites where he found typical Hittite pottery, and where consequently excavation may be expected to reveal Hittite settlements. Attention is largely directed to the numerous *hüyüks*, or mounds, found in this region, though Mr. Von der Osten was unable to excavate any, his investigation being for the most part restricted to superficial observation. Their position and obvious characteristics are described, but it is admitted that nothing precise or definite concerning them can be said until they are opened up by the excavator.

It is suggested that the flat tumuli in the valley of the Delidji Su were posts of a signal system, a part of the military organization by which the Hittite Empire maintained its supremacy. An indication of Egyptian and Hittite contact was the discovery at Kirik Kaleh of a black granite Egyptian statuette of the Middle Kingdom with a hieroglyphic inscription down the back. This and the material point to its origin being in Egypt itself.

But perhaps the most interesting of the author's investigations were those on the Kalehs with tunnels. In three instances such tunnels were examined, and were found to slope down by steps until stopped by stones and earth. Similar tunnels are also known in Phrygia and Armenia. They are usually situated in strategically important places and have generally been supposed to have been constructed to supply water to castles. Mr. Von der Osten offers a very different explanation of their use, viz. that they were military positions rendering possible the movement of troops out of sight of the enemy. It is difficult to assign a date, but he ventures to suggest that they may go back to Hittite times. The only discovery of Hittite sculpture was at Giaur Kalessi, where two large figures carved on the rock surface are well known. The author describes a third small seated

figure with conical headdress towards whom the other two are advancing. This figure is said to be shown on the last of the twenty-four plates which illustrate the volume. The present writer has however been unable to recognize such a figure in the photograph. It is suggested that here was the site of the ancient Kushshar, the royal city of the Hittites before they chose Hattushash for their capital.

A brief description is given of the position and surroundings of Boghaz Koi, and of the celebrated sculptures known as Yazili Kaya. Thirteen out of the twenty-four plates at the end of the volume consist of photographs of these bas-reliefs. Some are not as clear as might be wished. This section was evidently written before the detailed and very lucid description of the sculptures by Prof. Garstang, in his 'Hittite Empire,' had been published.

The volume is lavishly and admirably illustrated throughout, is finely printed, and is provided with a glossary index. E. A. P.

ERGEBNISSE DER SINAI-EXPEDITION 1927 DER HEBRÄISCHEN UNIVERSITAT, JERUSALEM. By F. S. BODENHEIMER and O. THEODOR. *Leipzig: J. C. Hinrichs* 1929. 9×6 *inches;* viii+142 *pages; and illustrations. M.*12

The authors of this book are zoologists on the staff of the Hebrew University of Jerusalem, and the principal object of their expedition to Sinai was to study the origin of the substance known as "manna." They are to be congratulated on the selection of a subject of such interest, the elucidation of which could be accomplished during a single expedition. The first twenty pages of the book are devoted to a brief account of the actual journey. The party landed at Tor in Southern Sinai on July 3; from here they went inland, later striking the coast farther north, and gradually working along it till Suez was reached, after a journey lasting eighteen days. The remainder of the report is devoted to an account of the zoological collections made, with special reference to the manna-producing organisms. The "tamarisk manna" of Sinai is the excreta of two insects of the genus Coccus (and to a much less extent of two other insects) and is analogous to the well-known honey-like secretion of the aphis. Details are given of the chemical composition of this manna, and it is noted that its crystalline composition (in fact, its existence) is only possible under the climatic conditions found in such a country as Sinai. Tamarisk manna has previously been regarded as exudation from the tamarisk itself, caused by the punctures of the insects, so that this expedition marks an important advance in the knowledge of the subject. L. D. S.

IM WELTFERNEN ORIENT. By ALFONS GABRIEL. *Munich and Berlin: R. Oldenbourg* 1929. 10×7 *inches;* xvi+366 *pages; illustrations and maps. M.*30

Dr. Alfons Gabriel's description of his travels in Persia is one of the most interesting and important works on that country which has appeared in recent years. Even if the author had confined his journey to the beaten tracks, his accurate descriptions, his keen power of observation, and his admirable photographs and sketches would still have made his book one of great value. Dr. Gabriel was however bent on exploring some of the less-known regions of Persia and, in spite of innumerable difficulties placed in his way and the slender resources at his disposal, he was able to visit and explore with remarkable thoroughness whole tracts of the country which are still but imperfectly known to travellers or geographers. From internal evidence—and it is slight enough—one gathers that Dr. Gabriel is an Austrian subject in the employ of the Java-China-Japan Line as a ship's doctor. He seems to possess a good knowledge of Persian and Arabic. In September 1927 he started with his wife on a journey to Persia *via* Egypt, Damascus, Baghdad, and Basra. From Basra he proceeded to Muscat and thence to Oman and from Oman to Bandar 'Abbas.

From Bandar 'Abbas he set out on March 3 for Minab with the object of making a tour in Bashagird. From Bashagird he proceeded *viâ* Bam to Kerman by a roundabout route bordering on the Desert of Lut, visiting Baluch Ab, Kashit, Karimabad and Khabis, finally reaching Kerman in the middle of June. Of this city the author gives a very interesting account, including a vivid description of the Muharram festivals celebrated there by the Shi'as during his stay. He had no plans for his further journey, but was at least determined not to use any of the three main motor roads leading to Yezd, Duzdab, and Shiraz respectively. He therefore made Tabas his objective and set out to cross the great desert Dasht-i-Lut, which separates the provinces of Khurasan and Kerman, the old caravan route followed in the thirteenth century by the Polos. From Tabas he journeyed to Tehran *via* Haluan and Khur, then, skirting the Kuh Dumdar, *via* Jandaq and Samnan and Qishlaq, reaching Tehran on October 8. From Tehran he returned by the ordinary motor road *via* Kazvin, Hamadan, Kermanshah to Baghdad and thence to Europe *via* Aleppo.

It is the journey into the district of Bashagird which constitutes the most important part of this work, in that it deals with one of the least-known regions in Persia. Curzon says: "It is a backward and impracticable region, consisting of a labyrinth of rugged hills, intersected by huge rocky watercourses, and containing a scanty population of half-naked savages, with a marked infusion of negro blood." The first white man to visit this dangerous country was E. Floyer, in 1876. In 1888 an English officer named Galindo, and in 1894 Masset and Medley, made expeditions into this country, the results of which have, unfortunately, never been made public. A few years later Sir Percy Sykes made the journey from Minab to Ramishk. During the Great War the English troops seem to have penetrated as far as the village of Karatan. In Minab Dr. Gabriel and his wife placed themselves in communication with Barakat-Khan, who was the ruler of Biaban and a large portion of Bashagird, and, thanks to his kindly aid and influence, they were able to make an extensive tour in this little-known and almost unexplored region.

With regard to the main types of inhabitants of Bashagird, Dr. Gabriel says it is difficult to make any definite pronouncement, and their origin is quite uncertain. Presumably the prevailing type is of Indian descent. In this connection the view put forward by Sykes cannot, he maintains, be ignored. From the researches of Dieulafoy and de Morgan, who discovered in the bas-reliefs of Susa many negrito types, Sykes suggested the possibility that these negritos peopled the whole of the north coast of the Persian Gulf as far as India, and that their descendants are to be found in the very dark-skinned population of the inaccessible and mountainous districts of Bashagird and the Sarhad. There seems also to be a strong admixture of Semitic blood in certain types.

In spite of his small equipment and of the dangers of the routes he traversed, Dr. Gabriel seems to have missed no opportunity of noting the flora and fauna of the country, and of collecting and bringing back with him geological, botanical, and zoological specimens, which he has submitted for examination to various specialists in Vienna. E. D. R.

THE HIMALAYAN JOURNAL: Records of the Himalayan Club. Edited by KENNETH MASON. Vol. 2, No. 2. *Calcutta and London: Thacker, Spink & Co. April* 1930. 9 × 5 *inches; 206 pages; illustrations and maps. 5 rupees or 8s*

The Himalayan Club is to be congratulated on its editor. The second volume of the *Himalayan Journal* more than maintains the promise of the first, with thirteen articles ranging from Chitral to Sikhim, thirteen notices of expeditions, besides Notes, Reviews, and Correspondence. It is perhaps not usual to review annual journals after the first number, but it is felt that a brief notice of this

volume should appear in the *Geographical Journal*, for it proves itself to be indispensable to all students of Himalayan geography, as well as to the votaries of other sciences and pursuits.

Both mountaineers and mountain topographers will read Mr. Burn's article on Istor-o-nal in the Tirich Mir group with great interest, for it breaks new ground. Colonel Tobin's article on the Sikhim Himalaya, followed by Herr Paul Bauer's modest account of the brilliant "Bavarian" attempt on Kangchenjunga in 1929 are the chief purely mountaineering contributions. The account of the prolonged tour of Mr. E. B. Wakefield, I.C.S., in Western Tibet in 1929 is of more geographical interest. At the end of August he found the channel between Manasarowar and Rakar Tal "deep and fast-flowing after recent rain" (p. 103). Our last previous information is General R. C. Wilson's, in *G.J.*, 71, 439. An anonymous correspondent sends a useful note on Samlakar and the Bodpo La, on the Tibet–Bashahr borders. There is an all too brief note on a very successful aeroplane flight to Gilgit along the "closed" section of the Indus. On p. 137 the latest measurements of the Fedchenko glacier is given as 48 miles, and on p. 120 the height of Peak Kaufmann is given as 23,382 feet. The Fedchenko glacier thus takes rank as the longest glacier outside the subpolar regions, being 3 miles longer than the more extensive Siachen glacier. Peak Kaufmann supersedes Trisul as the highest summit attained; for the latest available height of the latter is only 23,360 feet, or 46 feet lower than is shown on the old Survey maps. Colonel E. F. Norton contributes an interesting letter weighing the chances of success for this year's attempt on Kangchenjunga. Probably most mountaineers will agree with his opinion that the problem is even more formidable than that presented by Everest. Finally the chart to illustrate the Shyok Flood of 1929, together with that showing the periodicity of the Chong and Kichik Kumdun glaciers, compiled by the editor, read with the article (pp. 35–47), is of permanent value to all students of glacial phenomena.

The reviews of books are excellent. In fact, we have nothing but admiration for this number, and realization of what time and trouble it has cost the editor makes one feel that it would be utterly ungrateful to ask for an index. But the variety of subject and the number of topographical details from very widely scattered localities make it almost a book of reference. The number of individual contributors is the best testimony to the vitality of the Himalayan Club.

The reviewer still appeals to mountaineers to campaign in the "Simla sector," where the mountains are reasonably climbable by a small party of two or three, easily and comparatively cheaply accessible, and only Shilla and Leo Purgyal have ever been climbed. There are excellent articles on parts of this district by Messrs. Buchanan and Glover. T. G. L.

ORES AND INDUSTRY IN THE FAR EAST. The Influence of Key Mineral Resources on the Development of Oriental Civilization. By H. FOSTER BAIN, with a Chapter on Petroleum by W. B. HEROY. Preface by EDWIN F. GAY. *New York: Council on Foreign Relations, Inc.* 1927. 9×6 *inches;* viii+230 *pages; sketch-maps and diagrams.*

The origin and main conclusions of this book are set forth briefly by Prof. Gay in his introduction. He mentions the common assumption that the Far East countries, and China in particular, are possessed of immense mineral wealth, in addition to other resources in raw materials and man power, and that this wealth when organized will produce the fiercest industrial competition that the world has ever seen. Of recent years, however, this richness in mineral wealth, especially as far as China is concerned, has been seriously questioned. Mr. H. Foster Bain made a detailed examination of the subject and has prepared the present compact

volume on the mineral resources of the Far East. He and a well-equipped staff made elaborate field investigations in China, and, as the excellent bibliography shows, have made full use of all published information. He has come to the conclusion that China has abundant coal, antimony, and tungsten, and South-East Asia abundant tin, but that these complete the list of really considerable mineral supplies in the Far East. In particular none of the countries bordering the Western Pacific have resources of iron ore, actual or potential, that in quantity or quality range with the great deposits of the North American area. In the absence of supplies of iron ore neither Japan nor China can build up permanent industries of which these supply the central core. Their supplies, indeed, are only sufficient for the modest requirements of the immediate future.

In reading the main volume one is left with the impression that it is a well-balanced and well-documented statement of the position as known at present, and it leaves one very largely convinced that the author is correct in his general theme. His book represents the swing of opinion, and for that reason some of his estimates may be definitely on the pessimistic side. If Mr. Bain's estimates are correct, there is no doubt that there is comparatively little danger of the Far East in general, and China in particular, becoming a seriously disturbing factor in the economic life of the world in the near future. L. D. S.

THEN I SAW THE CONGO. By GRACE FLANDRAU. *London: George G. Harrap & Co.* 1929. 9 × 6 *inches;* 288 *pages; illustrations and sketch-maps.* 12*s*6*d*

The journey which is told remarkably well in this book was "inspired not by science but by curiosity," and it was in some rather ill-defined way mixed up with making a film, which the author did not take very seriously. She has a talent for recording conversations, with fellow travellers, officials, missionaries, and native servants: brief illuminating conversations that tell more than pages of description; a charitable view of the difficulties that beset the administration, and a charming sympathy with the good sides of the unspoiled native life where it is still to be found in the remoter Congo. "Babies in Africa never cry, and in all the time I was there I never saw a man or woman strike or even speak harshly to a child." "There must be very few boy choirs anywhere as beautiful as native choirs in the Congo." "Long after we went to bed the village remained awake—soft voices and soft laughter blending into a continuous stream of human sound, a singularly well-bred sound, like the talk in a decorous drawing-room at home." "As we walked back we passed an ugly tin-roofed shed, the only unlovely thing in the village. Under it sat the chief's eldest son with two secretaries, graduates, I suppose, of a Marist school. They were all dressed in duck trousers and were supervising the weighing of cotton and writing things in ledgers. When a chief dies his village is always destroyed, and the Court moves to the village of his heir. It is easy to imagine what will become of that fragment of an antique and beautiful tradition we had just seen when this business-like young man comes into his own."

She had intended to make simply a moving-picture of native life, but the professional in the party thought there was no use making a straight travel picture. The Mangbetus had to become actors in a highly elaborate plot; there was a pygmy sequence, a cannibal sequence, an elephant sequence. There were shots of ladies approaching cannibal village, close-ups of ladies looking into boiling pot and of human bones boiling in pot. "Well, how do you suppose most, I might say all, African films are made?—Is it all fake?—Not all. Only when it's necessary, which is usually." So in due course the "dear little conscientious pygmies, delighted to be the centre of attraction, lurked after the director. . . . They peered, beckoned, aimed poisoned arrows at our supposed safari, registering acute alarm and at all times the proper degree of wildness learned from the gestures of their

instructors . . . while Charlie implored hectically from behind the camera: 'Keep your shadows out of it—Get those other guys into the light.'"

But in the Congo you may meet more engaging people than camera men. There was Monsieur G., a banker, fastidious to a painful degree, with a horror of natives, who led a giraffe a thousand kilometres on a leash towards a Zoo in Austria; the museum in return named a small monkey after him. There was a little boy in Stanleyville in the ragged waistcoat of a dress-suit, playing a harp. And there was a party of American tourists "of some interest because of the singular air of gloom and fury that enveloped the little band." We have quoted enough to show that the author has a lively pen. She is not to be taken too seriously; but her account of the farm at Api where they tame the African elephant is of great interest, and there is a charming account of a tame okapi "which could not be dissuaded from following you about, his slender nose thrust forward, reaching for your chin, which he took very gently between his teeth and investigated with a very rough little tongue. A most beautiful, affectionate, and fearless creature." There are several delightful chapters on the villages of the Mangbetu, the finest architects in Africa, and with them the author becomes more serious. To visit them had been the principal aim of the journey, and though she avers that her sojourn of several weeks among them will throw no new light on "their lyric and inexplicable lives in their painted villages in the Ituri" one may well believe that her sympathetic pen has added something to the drier and more precise statements of Schweinfurth and Casati, whom she quotes in an appendix.

In any case, we may congratulate the author on a most spirited performance, as different as possible from the too frequent narrative of travel, and must recommend that none of the millions who will go to see the film shall do it without first reading the book. "Where," said the Authority in New York, "is the menace?" "Pardon *me*," replied the Biggest Cutter, "I believe I can take care of all that. All we gotta do is to graph the interest, redistribute the peaks, and potentialize the threat."

AIR PIONEERING IN THE ARCTIC: The Two Polar Flights of Roald Amundsen and Lincoln Ellsworth. By R. AMUNDSEN and L. ELLSWORTH. Part I. The 1925 Flight from Spitsbergen to 88° North. Part II. The First Crossing of the Polar Sea, 1926. *New York: National Americana Society* 1929. 14×11 *inches;* 56+126 *pages; illustrations and sketch-maps.* $35

The Society has recently been presented with a copy of the new and combined account of the voyages of the flying boats *N* 25 and *N* 26 in 1925, and of the airship *Norge* in 1926. The volume is a large one, and has been produced in much more lavish and more handsome form than is usually the case with polar books. Of the subject-matter most has already appeared in 'Our Polar Flight' and 'The First Crossing of the Polar Sea,' both joint works by Amundsen and Ellsworth. In the present volume however the illustrations are of fine quality, the margins wide, and the paper of best quality permanent rag; and nothing has been omitted to make the book as lasting as the fame of these two great expeditions. Amundsen had died before the book was published, but in Ellsworth he had the most loyal of friends, and a feature of the book is the very fine tribute which Ellsworth pays to Amundsen as explorer and hero. J. M. W.

STRUCTURE AND SURFACE: a Book of Field Geology. By C. BARRINGTON BROWN and F. DEBENHAM. *London: Edward Arnold & Co.* 1929. 10×6 *inches;* viii+168 *pages; sketch-maps and diagrams.* 10*s* 6*d*

The block diagram, showing simultaneously the surface relief and the underlying geological structure, has now gained general recognition as a most valuable adjunct to the teaching and to the study of geomorphology, and hence this little

volume, which deals primarily with the construction and use of such diagrams, will be welcomed alike by geographers and geologists. It is one of the regrettable consequences of over-much "book-learning" that the average student thinks in terms of lines rather than of surfaces, and in terms of surfaces rather than of three-dimensional figures. Recent developments in meteorology and oceanography have made it even more imperative to visualize solid figures, and it is to be hoped that a W. M. Davis will be found to adapt the block-diagram to the needs of these sciences also.

The simple introduction to Field Geology which the authors of the book before us have compiled is well suited to the needs of geography students, and should tempt them to more field-work than they usually undertake, but it is the diagrams that they will study most closely. These are of two types—idealized block diagrams of the simpler major and minor land-forms, and accurately drawn block diagrams of an actual tract of country where a particular structure is clearly exemplified. The frontispiece (showing the Craven Fault and Malham Tarn) well illustrates the skill with which the authors can handle the more difficult diagram of the second type, and makes one reader, at least, regret that they did not carry out their original plan of making the book simply a sequence of such pairs of blocks, omitting the general text which can be found elsewhere. As it is there are twenty "actual" examples out of a total of over one hundred diagrams, and it is to be hoped that the success of the present volume will lead the authors to prepare the sketch-book as originally conceived. E. G. R. T.

ADMIRALTY MANUAL OF NAVIGATION. 2 volumes. *London: H.M. Stationery Office* 1928. (Superseding 1922 edition.) 10×6 *inches;* viii+490 *and* viii+336 *pages; illustrations, charts, and diagrams. Vol.* 1: 6*s; vol.* 2: 4*s*

This manual is the standard work on navigational subjects in His Majesty's Fleet, and is designed to supply the needs of executive officers in general. Volume i is of a comprehensive but practical nature. Volume ii is of a more advanced character, and deals in a detailed manner with the theory of navigation and nautical astronomy and is especially intended for navigating officers. The 1928 edition is similar to that of 1922 in general arrangement and content, but certain subjects have been rewritten and new material has been introduced.

In volume i the chapter on Mercator's projection has been partly rewritten and an addition is given on how to construct a Mercator's chart. There is a new chapter on the great circle, and the sections on directional wireless, leader cable systems, and sound ranging have been considerably extended. An additional section has been introduced dealing with radio-acoustic sound ranging. The section dealing with the gyro compass appearing in the 1922 edition is now published as a separate manual and is therefore excluded from the present edition. For the first time mention is made of echo-sounding devices, but the reader is again referred to a separate manual on the subject. The chapter on tides has been completely rewritten and a new chapter on tidal streams introduced. The meteorological section is much enlarged, and a separate chapter is devoted to Synoptic Meteorology and the Upper Air.

New features of volume ii are a comprehensive chapter on hydrographical surveying, chapters on the wind and the ocean, the latter having much to say on the nature of waves, and a chapter on the Taut Wire measuring gear.

In the chapter on hydrographical surveying there is a section devoted to precise determination of astronomical position on land. It is curious that the methods advocated here do not include the combined determination of latitude and longitude by observations of altitudes of heavenly bodies at widely varying azimuths, as this method is essentially the same as position-line determination at sea, and

one would have thought that with the advent of wireless time signals this method would especially have appealed to the Navy. Brief mention, however, is made of "an astrolabe for determining latitude. This instrument consists of a fixed prism and makes use of an adaptation of the principle of equal altitudes."

On the whole, however, nothing but praise can be given this publication. The type is good and the diagrams and illustrations are excellent. Though principally intended as a reference book for the already trained officer, it is written in such a clear and concise style as to be admirably suited as a text-book for the student of navigation, and as such should have a wide appeal. This is especially the case in respect to the chapters dealing with trigonometry and terrestrial and celestial definitions. Mention should also be made of the Time Zone chart, which shows very distinctly the standard local time kept in all parts of the Earth. O. M. M.

A BIBLIOGRAPHY OF BRITISH NAVAL HISTORY: a bibliographical and historical guide to printed and manuscript sources. By G. E. MANWARING. *London: George Routledge & Sons* 1930.. 9 × 6 *inches;* xxii + 163 *pages.* 25*s*

The compiler of this handbook hastens, in his introduction, to remove any false impression which might be conveyed in the title. It is not a comprehensive bibliography of the subject, since it omits individual books which can be readily found from other subject catalogues. Its purpose is to make available material remaining in manuscript, contained in periodicals, or likely to be overlooked through inadequate titles. There are references to about 800 MSS., and several journals have been indexed. One item, classed as a MS., has already been printed by its present owner: 'Cartaret's Barbary Voyage, 1638,' by Mr. Boies Penrose of Philadelphia. Another qualification to the title is that the bibliography ends just after Trafalgar. It is in two parts, authors and subjects, and so arranged as to be handy and simple in use.

THE DESERT ROUTE TO INDIA: being the Journals of Four Travellers by the Great Desert Caravan Route between Aleppo and Basra. 1745–1751. Edited by DOUGLAS CARRUTHERS. London: Hakluyt Society (Series 2, No. lxiii), 1929. 9 × 6 *inches;* xxxvi + 196 *pages; illustrations and map*

The four travellers whose journals are reproduced in this volume are William Beawes, Gaylard Roberts, Bartholemew Plaisted, and John Carmichael. The narrative of Beawes, of his journey in 1745, printed from an India Office MS. for the first time, occupies forty pages. His description of Najaf is of exceptional interest; his views on the character and behaviour of the inhabitants are shared by much more recent visitors.

The narrative of Roberts, also from an India Office MS., of a journey from Basra to Aleppo in 1748, covers only five pages and contains little matter of interest. It may be noted that he estimates the cost of the overland journey from Basra to Aleppo by camel for a single man with only bare necessaries at Rs. 1600: the same journey by train (1st class) and car now costs the equivalent of about one-twentieth of that sum.

The narrative of Plaisted's journey in 1750 is a reprint from the first edition of his book, which is well known to students of this region, but gains new life and fresh interest from the editor's prefatory note, to obtain material for which must have involved a great deal of research. This note concludes with an account of Plaisted's death in the jaws of an alligator whilst he was surveying the Sundarbans in the Hooghly delta: the editor refers to this as "one small incident of his later years"—surely a perfect example of editorial meiosis.

Carmichael's narrative (forty-five pages) of a journey made in 1751 is also a reprint, but from a scarce and little-known source. It is in some ways more interesting than any of its predecessors. It is a careful and accurate route recon-

naissance: "over the sections," writes the editor, "which have been worked out, and tested against the most recent maps, his survey does him great credit." Carmichael's observations have repeatedly been used by geographers, notably by Rennell, but neither he nor Plaisted are mentioned by Alois Musil in his recently published volumes entitled 'Palmyrena' and 'The Middle Euphrates.'

The prefatory and editorial notes are in every case models of what skilled editing and patient research can do to make dry bones live. Mention might, however, have been made of the work 'Relation exacte concernant les caravanes ou cortéges des marchands d'Asie,' by M. Bugnon, Ingénieur en Chef et Géographe Militaire de S. A. R. (Nancy, 1707). Longrigg, in 'Four Centuries of Modern Iraq,' refers to two travellers not mentioned by Mr. Carruthers (because, it is understood, he was unable to trace them), namely, M. Carré, 'Voyages des Indes Oriental,' 1672–3 (Paris 1699), and Anonymous, 'Overlandries von India naar Europa in 1757' (Utrecht, 1860). In other respects, however, and within the self-imposed limitations of the editor, the bibliography is both comprehensive and accurate. A. T. W.

I VIAGGIATORI VENETI MINORI: Studio bio-bibliografico del Dott. PIETRO DONAZZOLO. (*Memorie della R. Soc. Geogr. Ital.*, 16.) *Roma:* (1929). 10×7 *inches;* 412 *pages. Lire* 40

Dr. Donazzolo has collected the references to the manuscript and printed sources for nearly four hundred Venetian travellers—he calls them "minor," since he omits the Polos, Oderic of Pordenone, and one or two others well known to historical geography. The great age of Venetian travel lay in the fifteenth and sixteenth centuries: later their journeys declined to ambassadorial tours in England, Poland, and other states of Europe. The compiler quotes the directions of the "Council of Ten" to intending travellers, extending to details such as the temperature, density of population, ancient and modern topographical names, and particularly the lineage and state of the ruler. The list includes such names as Giosafat Barbaro, Alvise da Mosto, and Antonio Pigafetta. For each, Dr. Donazzolo gives a brief biographical sketch, a list of secondary authorities, and finally, the works, manuscript and printed. The book should be particularly valuable for the key it provides to Venetian archives.

In detail, the volume is less satisfactory. Misprints are by no means covered by the list provided at the beginning. Other minor points are open to criticism—*e.g.* the date of Ramusio's 'Navigationi' is given as 1563–1606. The writer is wrong in criticizing Amat di S. Filippo for assigning without grounds the first edition of Bartolomeo de li Sonetti's 'Isolario' to 1485–1500. The book contains a cryptogram which refers to the first year, but more conclusively, the printer of the book is known to have worked from 1486–1494.

Where possible, some indication of the dates of the MSS. might have been given. It is often desirable to know what relation they bear to the printed versions. G. R. C.

EXPEDITION INTO NEW MEXICO made by Antonio de Espejo 1582–1583, as revealed in the Journal of DIEGO PEREZ DE LUXAN. Translated, with introduction and notes, by G. P. HAMMOND and A. REY. *Los Angeles: The Quivira Society* 1929. 10×7 *inches;* 142 *pages; illustrations and sketch-maps.* $3.50

THE CONQUEST OF PERU, as recorded by a member of the Pizarro expedition. Reproduced from the Seville edition of 1534, with a translation and annotations by JOSEPH H. SINCLAIR. *New York: New York Public Library* 1929. 12×9 *inches;* 47 *pages; and sketch-map.*

The Quivira Society has been founded to promote interest in the history of the "Spanish South-west" of the United States. Espejo's expedition into New

Mexico has been known in the past from his own report, a version of which, through a French medium, was translated and incorporated by Hakluyt in his 'Principal Navigations.' The account here published, forming Volume I of the Society's Publications, is a journal by a member of the expedition, Diego Perez de Luxan, which is preserved in manuscript in the 'Archivo General de Indias' in Seville. The editors claim that, since it was compiled as a diary, it is superior, as a documentary record of the expedition, to Espejo's report written on his return. The narrative is not in itself exciting, for on the whole the party was well received by the natives—though towards the end they felt compelled to burn and shoot a number as an example. It contains however much interesting information about the Indians and their pueblos, lying about the middle course of the Rio Grande, and to the west. They visited the famous pueblo of Acoma, seen by Coronado in 1540. Details are given of the dress, houses, food, and dances of the Indians, who seem to have been an attractive and amiable people. The photographs of their modern representatives and of localities mentioned in the text, add to the interest. It is a pity that the sketch-maps of the route were not more conveniently placed for reference from the text.

The second volume is a photographic facsimile of the anonymous Spanish narrative of Pizarro's conquest of Peru—'La Conquista del Peru'—written by a member of the expedition and printed at Seville in 1534. This is a bibliographical rarity, the New York Public Library possessing one of two known copies, and it is also valuable as the second printed account of the expedition. The other—Francisco Xeres' 'Verdadera Relacion de la Conquista del Peru,' also printed at Seville in 1534—is however much fuller and differs in some details. This anonymous account was apparently not known to Sir Clements Markham when he edited Xeres' version. By aiming at a faithful rendering of the original, the translator has preserved something of the breathlessness of the writer's style, who, if we may judge from one of the concluding paragraphs, wrote the 'Conquista' to support his claim to a larger share of the booty.

COLLECTIONS ILLUSTREES DES GRAND VOYAGES en Amérique au XVI^e^ siècle. Voyages en Virginie et en Floride: traduits du Latin par L. NINGLER. I. Description merveilleuse . . . des sauvages de la Virginie (en 1585) par THOMAS HARIOT. II. De trois voyages en Floride. [Ribaut, Landonniere, Gourgues.] Illustrations par THÉODORE DE BRY. *Paris: Duchartre et Van Buggenhoudt* 1927. 11×9 *inches;* XV+311 *pages; facsimile reproductions.* 20*s*

Published in 1927—but only recently bought for the Library—this work is worthy of a belated notice as being the first modern edition of de Bry's 'Grands et Petits Voyages,' published between 1590 and 1634. This might well have been made clearer in the title, where the illustrations alone are attributed to de Bry. The text has been translated into French for this volume; but, for later voyages, it is proposed to use original French versions wherever possible. All de Bry's frontispieces, maps and illustrations are reproduced, slightly reduced in scale (approximately to four-fifths). The book is well printed, though the illustrations naturally lack something of the strength of the original plates.

A short introduction describes briefly, and unfortunately, rather carelessly, earlier collections of voyages. Some of these errors are attributable to bad proof reading or mistakes in copying—the titles of several works are wrongly given—but others are due to misconceptions on the part of the writers. Peter Martyr's 'Decades' had been published many years before 1550, the first Decade appearing in his 'Opera' printed at Seville in 1511. Nor is it accurate to state that the first chapters were written in 1501, and then translated by Angelo Trevisan, to be

published as 'Libretto de tutta la navigazion.' The first letters date from 1493, and the version printed in the 'Libretto' was compiled by Trevisan from them, apparently without permission. Hakluyt's two works, of 1589 and 1599–1600, have been confused and run together. G. R. C.

THE HUNTING AND SPOOR OF CENTRAL AFRICAN GAME: with life-size Illustrations of most of the Game-Tracks. By DENIS D. LYELL. *London: Seely, Service & Co.* 1929. 10×7 *inches;* xiv+234 *pages; and illustrations.* 31*s* 6*d*

This is not the usual type of sporting volume that tells the story of an author's experiences in the pursuit of wild game. It is rather a book of practical instruction. It deals, for example, with the ethics of hunting, namely what is fair and what is unfair in the relation between hunter and game. It contains much information on the choice of weapons. The reader is admitted to the secrets of tracking. He will learn from it the different plans of hunting, the spots on the animal where he should direct his bullets, and how it will behave under different kinds of wounds. He is given many tips on practical matters, for example the best kind of tents to take, the requisite pattern of camp furniture and equipment, how to deal with native labour, how to improvise baths and beds, how to cure his trophies when they are secured, or himself when he is injured or sick.

But the most interesting feature of the book are the representations of the tracks made by the most important game animals of Africa. The largest, such as those of the elephant and rhinoceros, are necessarily reduced, but those from the buffalo downward are represented life-size. As in most books dealing with African game, the subject of animal colour is discussed. The author's views are particularly strong, and he has little respect for a certain class of opinions which to him are the inexperienced emanations of "study-naturalists from their musty dens." Indeed, he seems to have little appreciation of the difficulties that beset the biological investigator. He writes as though it were a matter of comparative ease for the entomologist to discover some kind of fatal malady that could be transmitted from tsetse fly to tsetse fly so as to sweep them off the face of the earth. R. W. G. H.

THE EMPIRE IN THE NEW ERA: Speeches during an Empire Tour, 1927–1928. By The Rt. Hon. L. S. AMERY, M.P. (With a Foreword by the Rt. Hon. the Earl of Balfour.) *London: Edward Arnold & Co.* 1928. 9×6 *inches;* xii +306 *pages.* 15*s*

Mr. Amery's tour of the Empire included South Africa, Australia, New Zealand, and Canada. The first of these speeches was delivered at a Civic Reception in the town hall, Cape Town, in August 1927, the last at the Canadian Club Dinner at St. John's, New Brunswick, in February 1928. He went, as he says, to learn, and, as the speeches show, also to preach the ideas that inspire the policy of the new Imperial era, defined in 1926, "the policy," as Lord Balfour in his impressive foreword describes it, " of equal status and free cooperation." These ideas give a unity to the speeches in all the variety of their circumstances. The journey, undertaken at such a time, must have been of singular interest and, one may well believe, fruitful for both sides, and in the ever-changing conditions of the modern world and of young and growing communities, a most desirable, if not essential, means of maintaining that mutual understanding necessary for free cooperation. The speeches are clearly and vigorously expressed, and always interesting, though they contain much repetition. A diary might have been more instructive, for we could do with another 'Greater Britain,' describing the conditions and problems of the Empire to-day, as Sir Charles Dilke described them sixty years ago; but the speeches will stand as the expression of a new policy and a new spirit. E. A. B.

ALLGEMEINE WIRTSCHAFTS- UND VERKEHRSGEOGRAPHIE. By Dr. K. SAPPER. 2. Aufl. *Leipzig and Berlin: B. G. Teubner* 1929. 9×6 *inches;* viii+392 *pages; sketch-maps and diagrams.* 18 *Marks*

This second edition follows the general lines of the first, published in 1925, but it has been revised, considerably augmented, and the statistics brought down to 1927 where possible. The section on trade and traffic has been re-written, emphasizing the historical and cultural aspects in place of the predominantly regional treatment in the earlier edition, and two chapters have been added, one dealing with the frequently neglected subject of consumption, the second with the influence of settlement, economics, and traffic upon the "Landschaftsbild"—a branch which has recently been developed in Germany. It will be seen that the changes in this edition bring the book more into line with its title; the emphasis is now almost entirely upon "Allgemeine," regional treatment being excluded. Dr. Sapper's principal aim has been to abandon the "West-European" standpoint, and give equal treatment to all the cultural areas of the world. He describes the influence of natural forces upon human economy, and then the reaction to them and to his environment of man as an "economic animal." Here he lays stress upon the hindrances to development, the difficulty of acclimatization, the ravages of disease, and even the multiplicity of languages. One commendable feature is the introduction of first-hand descriptions of life and work in various countries, which might have been extended. Impressions gained by the author in a recent journey in South America have also been included. He confesses, apparently regretfully, that political considerations, which must obviously affect economic exchange, have been omitted. A similar subject which might have been treated is the effect of social organization. A statistical appendix and bibliography complete the work.

SUBJECT CATALOGUE OF THE LIBRARY OF THE ROYAL EMPIRE SOCIETY. By EVANS LEWIN. Volume 1. The British Empire generally, and Africa. *London: Royal Empire Society* 1930. 12×9 *inches;* ix+139+582+cxxiii *pages. Three guineas for three volumes*

This subject catalogue will, when complete, form a useful guide to the literature on the British Empire, in all branches. The main classification is regional, with sub-divisions by subject. But there is also an author index, giving page references to the preceding section. The volume includes most of the official literature on Africa published since 1910, with a selection from earlier years. The work has been done in great detail. References to articles in periodicals, and even in newspapers, are given, and, for many of the books, chapter-headings or other indication of their contents. In addition, titles are often given at great length, and books entered under several headings (the author index repeats each of these without discrimination). It might have been possible, without impairing the usefulness of the work, to condense this material. Details of the title, etc., could always be obtained from the author catalogue. A small point, which may be worth noting, concerns the entries relating to serials. These are placed at the end of the respective sub-divisions, though there appears to be no definite indication of this: perhaps a better method would have been to group all the serials together for more rapid reference.

THE MONTHLY RECORD

SAXTON'S LARGE MAP OF ENGLAND

When, four years ago, Sir George Fordham drew attention in this *Journal* (vol. 67, p. 63) to the existence of copies of Saxton's large map, which had been strangely ignored by writers on British Cartography, he showed that none of the known copies represented the original issue, the discovery of which was pointed out as a desideratum. Mr. Francis Edwards has now been fortunate enough to meet with a copy in the original state, which has lain hid, it seems, in the recently dispersed library of the Hare family at Docking Hall, in Norfolk. He has courteously left it with us for examination, and we are thus able to give some notes on points of interest which it presents.

As mentioned by Sir George, the British Museum possesses a copy (catalogued as of "1630 ?") which when he wrote came nearer the original state than any of the others known, these being either of the late seventeenth or the eighteenth century. In the later issues there was evidence of much alteration, notably in the insertion of roads and additional place-names, while the original Elizabethan ships, scattered over the coastal waters, had been replaced by others of a later type. In the earliest B.M. specimen, the original ships were still there, but the whole upper right corner, containing in later copies the title and the Royal Arms in an elaborate form, was blank, as were also the spaces allotted to two long inscriptions on the left. As the paper is of the second half of the seventeenth century it seems evident that this copy represents a set of proofs taken during the preparation of the transformed version, issued by Phillip Lea about 1688. The copy now discovered gives us for the first time the original title, with the coat of arms as borne by Elizabeth, together with the date 1583 and a long inscription concluding with a dedication to the Queen by Seckford, Saxton's patron. The copy owes it preservation to the fact that it is not mounted as a whole, but the twenty sheets are bound in a folio volume. A small detail thus preserved is the double series of marginal sheet-numbers, evidently intended as a guide to alternative methods of arrangement, in transverse or vertical rows. The former is followed in the present copy. Unfortunately, the engraver's name nowhere appears, and the map may be the work of more than one hand, but the decoration and the fine style of the larger inscriptions somewhat recall the work of Ryther, one of the engravers of the County maps.* The small names are in less attractive script, but this may be due partly to the way in which they are crowded together in places, for though the scale is much smaller, room is found for a large majority of the names inserted in the County maps.

It may be noted that while the County maps have no indication of latitude and longitude, the large map has the degrees and minutes marked round the margin. This shows that Saxton was remarkably correct in his latitudes, and one would like to know how far this was the result of astronomical observations. (In longitude he somewhat exaggerated the extension of Southern England.) The large map gives a scale of three different miles—*magna*, *mediocria*, and *parva*, the last being equal to the minute of latitude—whereas only one is shown in the County maps, which apparently use the long mile of about 11 furlongs. As Mercator shows the same three miles in one or other of the English maps in his Atlas, it might be thought that he based these on the general rather than on the County

*The particular pattern of the pair of compasses above the scales of miles in the big map is to be seen also in all but one of the County maps bearing Ryther's name, and in none of the others. The large letters of some names, written in outline in the original, are filled in solid in the later issues.

maps. Yet he appears to have used the latter too, as he gives a good many more names than are found in the general map. His latitudes are strangely incorrect in the English maps, Berwick being placed north of 57°. He had come nearer the truth in his Europe of 1554.

Although the newly found Saxton no doubt preserves the original state of the map it may possibly not be a contemporary impression, for most of the paper bears a mark current (apparently for no long time)—about, or rather after, the middle of the seventeenth century. The binding is old, and the fact that two at least of the three maps inserted at the end are of the second half of that century fits in with this suggestion.

Mr. Edwards has also secured a copy of Lea's issue, put up in a somewhat unusual form, as a roll composed of five strips of varying length, each comprising a complete belt of country running east and west, but omitting most of the sea-surface and the accompanying embellishment. This may have been merely a whim of the owner, but such a make-up may have been in the publisher's mind, for the scale of degrees is printed at the foot of each strip, while the names of the counties are given along the tops, and place-names are often inserted outside the lines of junction of the sheets. The imprint " Sold by Phillip Lea Globe Maker London" appears (above Norfolk) at the top of one of the strips, which possibly implies that the general title with Lea's name was not included in this form of issue.

LIVERPOOL OBSERVATORY AND TIDAL INSTITUTE

Since 1 January 1929 the Liverpool Observatory of the Mersey Docks and Harbour Board has been united with the Tidal Institute of the University of Liverpool to form a single institution known as the Liverpool Observatory and Tidal Institute. The government of the institution is in the hands of a Joint Committee appointed by the Board and the University, and its Director is Professor J. Proudman. The funds of the institution are partly derived from grants from the Board, the University, and the Liverpool Steamship Owners' Association, and partly from work done on the analysis and prediction of tides. Smaller sources of income are the supply of meteorological information and the testing of chronometers, sextants, and other instruments. The first annual report of the institution, for 1929, is very similar in appearance and content to the previous reports of the Tidal Institute of the University of Liverpool. Among the research papers mentioned as published since the last annual report of the Tidal Institute, issued in July 1928, the paper by Dr. S. F. Grace on "Internal friction in certain tidal currents" (*Proc. Roy. Soc.*, vol. 124), throws some light on the obscure problem of turbulence in the sea. Professor Proudman's study of "The effects on the sea of changes in atmospheric pressure" includes an explanation of the exceptionally large wave in the English Channel on 20 July 1929 (described by Captain C. K. M. Douglas in the *Meteorological Magazine* for September 1929), which takes into account the rate of travel of a line-squall and of the associated disturbance in the sea. Under certain conditions, when the rate of travel of the squall is nearly equal to that of a free wave in the sea, large disturbances are produced.

By a new scheme, introduced by Dr. Doodson, all meteorological observations at the Observatory made on one day are now entered together on one page, with abstracts from the self-recording instruments, together with certain regular daily reports. Weather and visibility are given special attention, so that the facsimile extracts from the diary issued give daily weather reports adequate for all the requirements of the port. A meteorological summary for 1929 calls attention to the abnormality of the distribution of rainfall over the year at the station. The rainfall for the first six months of 1929 was only 54 per cent. of the normal, that

for March, 0·283 inch, only 16 per cent., while that for November, 4·524 inches, was 177 per cent. The output of tidal predictions, mainly supplied to the Hydrographic Department of the Admiralty, and including predictions of the time of slack-water of tidal currents, always regarded as an important side of the work of the Tidal Institute, was very great in 1929. A list is given of the ports for which predictions were supplied in 1929, with details as to the year for which the predictions were made, and the ownership of the copyright.

GLACIATION OF THE WELSH MARCH

The increasing number of studies on local glaciations shows that geologists are beginning to work out the topographical details of the generalized Ice Age with, perhaps, as much certainty as is possible on the purely circumstantial evidence of past ice-action.

The present study by Dr. A. R. Dwerryhouse on the "Glaciation of Clun Forest, Radnor Forest, and some adjoining Districts" deals with an area of some 1000 square miles embracing Radnorshire, and parts of Montgomeryshire, Shropshire, Brecknockshire, Herefordshire, and Worcestershire [*Quart. Journ. Geol. Soc.*, vol. 86, part 1, 1930]. The highly complex structure and relief of the region, to which, indeed, it owes much of its remarkably beautiful scenery, is partly connected with the effects of ice, and some of the Shropshire dingles, such as Marrington Dingle, are considered to have been cut by the escaping waters during the retreat of the glaciers.

The area was glaciated by ice having its origin in the highlands of Central Wales. This ice accumulated in the depression that now forms the valleys of the Irthon and the Irfon until it found an escape by the Upper Severn on the one hand, and the Wye Gorge below Builth on the other. But during this accumulation it rose high enough to overflow the higher ground of Clun Forest, and to reach as high as 1700 feet on Radnor Forest, which obstructed its eastward flow. Many streams were deflected from their former courses, but the most interesting case is that of the Teme, now one of the chief feeders of the Severn. This was deflected by the formation of a glacial lake in the Vale of Wigmore by way of the Downton Gorge into the valley north of Ludlow, and later by the ice-front and moraine at Orleton into its present course past Tenbury, and thence across the Malvern axis into the Severn. The Orleton moraine is a ridge of gravel about 50 feet high, cut through by the main line between Hereford and Shrewsbury, dividing the drainage systems of the Lugg and Teme. It represents the northward limit of the drift of the Wye Glacier on the Hereford plain. The watershed between the Teme and the Lugg is here extremely vague and indefinite, lying in a broad flat marshy valley, containing ditches with hardly any flow, and quite clearly a continuation of the Upper Teme which in Pre-Glacial times flowed southward *via* the Lugg into the Wye.

It is inferred that the maximum extension of the Welsh ice was subsequent to the greatest extension of the Irish Sea Glacier on the Shropshire Plain.

INTERNATIONAL CONGRESS OF HISTORICAL GEOGRAPHY

At the Sixth International Congress of Historical Sciences held at Oslo in 1928, a special meeting was devoted to the subject of historical geography and a sub-committee of historical geography formed to prepare a scheme of international agreement and coordination of cartographic method. An International Congress of Historical Geography has now been arranged, to be held in Brussels from 11–14 August 1930. His Majesty King Albert is Patron of the Congress, Professor Henri Pirenne Honorary President of the Honorary Committee, and Professor H. Vander Linden President of the Organizing Committee. A detailed

programme has not yet reached us, but in the notice so far received it is stated that the committee was considering the possibility of holding one meeting, specially devoted to linguistic geography, in Liège, and another, dealing mainly with historical cartography, in Antwerp. The date of the Congress coincides with that of the International Exhibitions of Liège and Antwerp and of the celebration of the Centenary of the Independence of Belgium. A special exhibition of maps, plans, and engravings bearing on historical geography will be arranged in the Royal Library of Brussels. The General Secretary of the Congress is Professor F. Quicke (3 Avenue Saint-Augustin, Forest-Bruxelles, Belgium).

ICE ON THE GERMAN COASTS

For the past twenty-five years annual reports on conditions of ice and navigation on the North Sea and Baltic coasts of Germany have been published regularly in the *Annalen der Hydrographie*, the organ of the German Hydrographical Office, and a summary of the observations in tabular form, with some of the general conclusions to be drawn from them, has now been published in the *Annalen* for 15 January 1930. Although their interest is primarily economic they are useful also for the light they throw on the interrelations of ice-formation with other physical conditions. Owing to the paucity of stations in the open sea the observations relate in great part to the coastal waters, but it is noted that even in the Baltic it is only in the northern and central area that yearly freezing of the open sea takes place, and serious obstruction to navigation by drift-ice has only occurred in ten winters since 1896. By contrast, hardly a winter passes without ice-obstruction of the channels leading to the ports, and of the coastal lagoons. In accord with the generally longer duration and greater intensity of frost in the more eastern waters, ice-obstruction is progressively greater in the same direction. Yet within limited stretches there are marked differences, less ice being found at open spots with deep water, exposed to winds and tidal action, and much frequented by shipping. In the North Sea the less favourably placed spots are the mouths of the Eider, Elbe, and Ems, while in the Baltic the Frische Haff and other enclosed waters show the greatest number of ice-days. While the minor hindrances to navigation follow as a rule the local fluctuations in the number of ice-days, no such clear relation is seen in regard to complete closing of navigation. This is a common occurrence in the Baltic, but much rarer in the North Sea waters. The favourable conditions at Danzig in comparison with its easterly position may be ascribed in part to the prevailing southerly winds, which carry the ice rapidly out to sea, in part also to the quantity of shipping which frequents the port. That Stettin is rarely closed to navigation is again partly due to the activity of the port, partly to the use of ice-breakers.

INTERNATIONAL MEDITERRANEAN RESEARCH ASSOCIATION

On 11 April 1929 a distinguished assembly representing the Academies, Institutes, and Schools of many nations in Rome and Florence, met in Rome to consider the proposal of Count Costantini, President of the Italian Institute of Human Palaeontology in Florence, and of the International and Palaeographic Commission, to form in Rome an Association for the advancement of the study of the Mediterranean civilizations. The outcome of this meeting was the incorporation on 28 June 1929 of the International Mediterranean Research Association, whose headquarters are at Villa Celimontana, Rome. Count Costantini is the first President of the Association, Dr. G. Calza is Secretary General, and Dr. A. Formichi is Director. The purpose of the Association is stated to be "to promote the advance and diffusion of knowledge of the civilizations which flourished or left a record throughout the ages in the Mediterranean basin, and to further the main-

tenance, the restoration, and research into, all monumental and documentary evidence thereof." A bi-monthly Bulletin (*Bollettino dell' Associasione Internazionale degli Studi Mediterranei*) is to be published which "will endeavour to supply news concerning the trend of scientific research in various countries which bears upon the advancement of knowledge of the Mediterranean civilizations." It will publish manuscripts written in any of the six languages: Italian, English, French, German, Latin, and Spanish. The first number, for March 1930, contains, besides a number of short articles in Italian, summaries of some of the recent American, French, English, German, and Italian investigations in various parts of the Mediterranean. The Bulletin is illustrated by a number of fine photographs mainly of archaeological sites.

A BREEZE IN TRINIDAD

We are indebted to a correspondent in Port-of-Spain for a copy of the *Trinidad Guardian* of 9 April 1930 bearing on its front page in large and leaded type this "period piece":

TRINIDAD EXPLORER SPEAKS OUT

"Chaffanjon never discovered the source of the Orinoco," declared Mr. Henry Caracciolo, Port-of-Spain's veteran naturalist and scientist, in an interview with a TRINIDAD GUARDIAN representative yesterday. Thus with dramatic swiftness, impartial Trinidad testimony has descended to vindicate Dr. Dickey and the adventurous members of the American expedition which is passing through Trinidad in an attempt to discover the source of the Orinoco.

News of the arrival of the expedition in Port-of-Spain was first exclusively reported in the TRINIDAD GUARDIAN and within a few days later the *Port-of-Spain Gazette*—true to its policy of belittling this newspaper's superior news service and soaring circulation—featured an anonymous letter which alleged that the Orinoco source had already been discovered by a French explorer; and in a later article a staff-writer referred in scathing terms to "Notoriety hunters" and "would-be discoverers" of facts already well-known to the scientific world. The general public will treat feverish attacks on Trinidad's biggest and brightest morning newspaper with tolerance, but a public attack on Dr. Dickey and his expedition is another matter. In the interests of science, and hospitality to our visitors, a public withdrawal of the insinuations should be forthcoming immediately.

According to the *New York Times* as quoted by the *Trinidad Guardian*, it is Dr. Dickey's theory that natives have attacked other explorers through fear, and that the presence of a white woman will assure them that no harm is intended. We may hope that his theory will prove well founded. The experience of Dr. Hamilton Rice when he reached the "Raudal of the Guaharibos" in 1920 is not encouraging (*G.J.*, 58, 1921, pp. 340–342). Chaffanjon did not claim that he reached the source of the eastern head-stream of the Upper Orinoco, but a point where that stream was only 5 yards wide, coming down from the conspicuous peak which he named "F. de Lesseps," not more than about 20 miles away. It will be remembered that Dr. Hamilton Rice approached the same region from the east by the Parima in 1924, and got within about 60 miles of the peak. His air photographs show a difficult forest-clad mountain country (*G.J.*, 71, 1928, pp. 113–143, and 345–357). Within this unexplored region there is room for a hundred small headwaters of the Orinoco and Parima, and there is really small geographical interest in arguments about the "actual source" so dear to newspapers and record makers.

WIRELESS STATION IN FRANZ JOSEF LAND

The establishment of the most northerly wireless station and observatory, on Hooker Island, in the Franz Josef Archipelago, is recorded by Prof. R. Samoilovitch in *Petermanns Mitteilungen* (Hf. 5–6, 1930). The party left Archangel on 20 July 1929 on the icebreaker *Ssedow*. Four days later the first ice was encountered; the sea south of the archipelago was thickly covered, and it was necessary for the vessel to break a way through. The south coast of Hooker island was visited, also Newton island and Northbrook island, the latter by sledge, as the vessel was unable to penetrate the ice. The site selected for the station is Calm Bay, in the north-west of Hooker Island, the winter quarters of the Ssedow Expedition, 1913–14. Here the buildings were put up in twenty-four days: the wireless station operates on a short wave length, but receives long and short waves. Meteorological and aerological instruments have also been installed. It is hoped that in the next two years the station will be fully equipped for participation in the work of the proposed International Polar Year, 1932–3. While the station was being built, the *Ssedow* made two trips to the north for oceanographical research. Nansen island was examined by geologists; on the second voyage the *Ssedow's* course lay through the British Channel to 82° 14′ N. This channel and Queen Victoria Sea were practically ice-free, in contrast to the sea south of the archipelago. This is probably due to a warm current from the Atlantic. The oceanographical work was continued on the return to Archangel via Novaya Zemlya. The paper is accompanied by a sketch-map which shows the ice-conditions in the surrounding sea.

RAILWAY DEVELOPMENT IN NYASALAND

The progress of Nyasaland has been much hampered by the unfavourable conditions of access to the sea, and for some years the means of improving these have been under consideration. Three different railway companies have been concerned with the transport of produce to Beira, and the Zambezi, with its great fluctuations of level during the year and constantly shifting sandbanks, has involved a serious break in the chain, so that the question of bridging it had engaged attention even before the war. In 1926 the matter was seriously taken up by the Colonial Office, and a Commission of three members—Brig.-Gen. F. D. Hammond, Major E. O. A. Newcombe, and Mr. E. P. Carter—went out before the end of the year to study the conditions on the spot. Their report, though dated 31 May 1927, was not printed till last year, but is of present interest in view of the recent announcement that a scheme has at last been adopted for the fusion of the three railways concerned, and the building of a bridge over the Zambezi, which, with other minor extensions, will give a continuous line from Nyasa to Beira. The capital outlay is reckoned at somewhat over three millions, which the Nyasaland Government has agreed to provide, subject to certain conditions. The report of the Commission deals with the possible development of exports from and imports to Nyasaland given suitable transport facilities both from the sea and to the remoter parts of the Protectorate, basing the estimate on the actual figures for recent years. Hitherto the parts best served by the existing railway have been responsible for over five-sixths of the total production, by far the most important item in which is tobacco, this being followed after a long interval by tea, sisal, and cotton. The total production for 1926 was a little over 7000 tons, while it is estimated that when, in addition to the main scheme, the northern area is better provided with transport, the figure might reach 18,000 tons within a few years. Much of the report deals with technical matters relating to the improvement of the railway system, and the alternative proposals for the bridge, the original concession for which was granted by the Portuguese Government so far back as

1912. The existing ferry, which under great disadvantages forms the link between the Central African Railway on the north and the Trans-Zambezi railway on the south, plies between the respective termini at Chindio and Murraca, but this site is unsuitable for a bridge by reason of the width and shifting sand-banks of the river at this spot and the liability to flooding of a very wide area on either side. It is therefore proposed to build the bridge 25 miles higher up, at a spot where the river is confined within well-defined banks, with a permanent navigable channel. Under normal conditions the width is only about 1 mile, increased to 2 at high-flood level. The contract with the Portuguese Government provided that the bridge shall not interfere with the free navigation of the river, so that there must either be an opening span to allow vessels to pass, or the bridge must cross the navigation channel at a high level. The latter alternative is considered by the engineers to be the more suitable and it is to be presumed that it will be adopted.

THE EAST AFRICAN MOUNTAIN CLUB

We have received from Mr. P. Ungerer, the Honorary Secretary and Treasurer, a prospectus of the East African Mountain Club which has been formed to assist persons desirous of climbing the summits of the Kilamanjaro massif; to arrange for capable guides and porters; to maintain the present three huts on the range; to build a new hut near the caves at 15,000 feet; and generally to encourage climbers and visitors to the district. The annual subscription is ten shillings, and there is no entrance fee during the present year. Applications should be made to the East African Mountain Club, addressed to its headquarters, P.O. Box 5, Moshi, Tanganyika.

OBITUARY

FRIDTJOF NANSEN

Fridtjof Nansen was born at Fröen near Christiania on 10 October 1861. His early years were spent in the country, and even as a schoolboy he attained a high proficiency on ski and in other outdoor sports. The country life also gave him his love of natural history and a fondness for the hills and lonely places. At the age of nineteen he entered Christiania University, and two years later made his first voyage to polar seas in the sealer *Viking*, which cruised between Greenland, Jan Mayen, and Spitsbergen. When the ship was drifting in the ice off East Greenland Nansen first pondered over plans for reaching the coast and penetrating the unknown interior. On his return from this cruise, when he became Curator of the Bergen Museum, Nansen started to mature his bold scheme. Until A. E. Nordenskjöld, in 1883, penetrated eastward about 60 miles from Disko Bay nothing definite was known of the interior of Greenland. Nansen proposed to cross on ski from east to west, holding that the lack of a base on the uninhabited east coast to fall back upon and the lure of safety in the inhabited west would be valuable stimuli. As he put it, "Death or the west coast of Greenland" would be the order. The Norwegian Storting refused financial support, which however was provided by Herr A. Gamel of Copenhagen. In 1888 Nansen sailed in the sealer *Jason* with O. Sverdrup, O. Dietrichson, K. Trana, and two Lapps. He wanted dogs, but was unable to obtain satisfactory ones in time. Reindeer offered too many difficulties in transport. Nansen's project included making the land across the moving pack of the East Greenland current after leaving the ship. The

Jason approached the coast in about lat. 66° N., but could not get within reasonable distance for landing the party until it had drifted much farther south. Eventually the party left the ship in two boats about 10 miles from the shore, and after twelve days' drifting reached the coast in lat. 61° 30′ N. In open water they made their way north to lat. 64° 22′ N., where the ascent to the ice began. It was too late in the season to attempt the long crossing to Disko, so Nansen decided to make for Godthaab. In forty days, after rising to 8900 feet, Ameralik fjord was reached, and from there in a boat roughly constructed from willows and canvas, the party made its way to Godthaab. They returned to Norway the following summer. The expedition was the first to show the nature of the interior of Greenland, and it proved beyond reasonable doubt that a lofty ice-sheet covered the greater part of the island. There have been many later and wider crossings of Greenland, but it was Nansen who showed the way and methods of travel for the ice-cap.

In 1890 Nansen communicated to the Norwegian Geographical Society, and in 1892 to this Society, his plans for a bolder and more important expedition ("How can the North Polar Region be crossed?" *Journal*, 1, January 1893). Arguing that the failure of all attempts to reach the North Pole and even to penetrate the inner Arctic regions were due to drifting ice-floes that either stopped the ship or thwarted sledge travellers, he proposed to entrust his ship to the drifting ice and move with the pack. He adduced proof of a transpolar current from Bering Strait to Spitsbergen and Greenland, and he planned to build a small strong wooden ship of such a shape as to lift under heavy ice pressure and lie upon the floes supported by ice beneath. Small sealing vessels often behave like this and so escape destruction. Nansen held that his ship, drifting with the transpolar current, would carry his party across the Arctic Sea in two years' time. "It may be possible that the current will not carry us exactly across the Pole, but the principal thing is to explore the unknown polar regions, . . ." The project met with even more adverse criticism than his Greenland plans several years earlier. But Nansen was always sure of himself, and held to his opinions. The Norwegian State found two-thirds of the money and King Oscar and others subscribed the rest. Nansen's reputation was established in Norway and he had no longer to go abroad for financial support. The *Fram*, with a complement of thirteen, left Norway in July 1893 under Captain O. Sverdrup. In September of the same year, after coasting along Europe and Asia, she entered the pack to the north of the New Siberian Islands, and the long drift began. Everything went according to plan. The drift, though slow and at times confused, carried the ship onwards. However, in March 1895 it was apparent that the course would not be across the Pole. Nansen then took one of the most daring steps in the history of polar exploration. With H. Johansen, 28 dogs, 3 sledges, 2 kayaks, and 100 days' food, he left the *Fram* in an attempt to reach the Pole over the drifting floes, with the hope of returning to Spitsbergen. In twenty-three days they gained the record latitude of 86° 14′ N. and deemed it unwise to go farther. By the middle of August they reached Jackson Island in Franz Josef Land and spent the winter there in a rough hut of stones, living chiefly on bear's meat. From there in spring they travelled south along the ice in British Channel, intending to push west to Spitsbergen. On 17 June 1896, near Cape Flora, they met Mr. F. G. Jackson and Mr. A. B. Armitage of the Jackson-Harmsworth Expedition, and in a few weeks returned to Norway in the *Windward*. Within a few days the *Fram*, liberated from the pack on the north-west of Spitsbergen, arrived safely at Tromsö.

The expedition afforded ample proof of the soundness of Nansen's theories and his methods. It had moreover no rival in the importance of its results. Through a long period observations were made in meteorology and oceanography

in high latitudes, and the existence of a deep polar basin devoid of large land masses was established. In fact, the available sounding wire proved inadequate for the depths in several places. The attention paid to scientific problems raised the standard of polar exploration, and the methods used added to the technique of polar travel and did something to dispel the old-time terror of the Arctic. Much Arctic exploration has been done since the voyage of the *Fram*, but it is noticeable that little has been added to our knowledge of the Arctic basin as apart from the continental shelf of bordering seas.

On his return Nansen became the hero of the hour. Among a shower of honours he received a special medal from this Society presented by the Prince of Wales at a great meeting in the Albert Hall on 8 February 1897. He had already received the Patron's Medal in 1891 for his work in Greenland. The British Government suitably presented him with a set of the *Challenger* Reports. The scientific results of the *Fram* expedition were published in six volumes, and were to Arctic oceanography what the *Challenger* results had been to the oceanography of other oceans.

In 1900 Nansen, who for some years had been Professor of Zoology at Christiania University, became Director of the International Laboratory for North Sea Research at Christiania and made an oceanographical cruise in the eastern North Atlantic in the Norwegian research vessel *Michael Sars*. This began a series of important researches into the oceanography of the North Atlantic and Greenland Sea which included a visit to Spitsbergen waters in his yacht *Veslemöy* in 1912 and to the Kara Sea in 1913. These investigations were corollaries to work begun in the *Fram* and threw light on the origin of the water in the Arctic basin and the movements of currents at different depths. Some of the work was done in conjunction with Prof. B. Helland-Hansen and other Norwegian physicists. Among numerous papers on this work may be mentioned: "The Norwegian Sea," *Rep. Nor. Fish. and Mar. Investigations*, 1909; "On the Waters of the North-Eastern Atlantic," *Inter. Revue Hydrol. and Hydrog.*, 1913; "Northern Waters," *Videns. Sels. Skrifter*, I, 1906; "Spitsbergen Waters," *Videns. Sels. Skrifter*, I, 1915. Other important researches were into the origin of the low rocky platform on the coast of Norway and many Arctic lands, and the formation of the wide continental shelf around the Arctic Sea. These appear chiefly in "The Strandflat and Isostasy," *Videns. Sels. Skrifter*, I, 1921. In 1908 he was made Professor of Oceanography at Christiania University. Nansen's interests were not however confined to physical problems. Researches into the share of the early Norsemen in Arctic exploration led to his scholarly treatise on the whole subject from the earliest times to the fifteenth century, entitled 'In Northern Mists' (1911).

A growing demand in Norway for the dissolution of the union with Sweden came to a head early in the century and found a strong advocate in Nansen ('Norway and the Union with Sweden,' 1905). On Norway's independence being obtained in 1905 Nansen became Norway's first Minister to the Court of St. James, a position which he held until 1908. In 1906 he was made an honorary G.C.V.O.

During the European War Nansen went to America on behalf of his country to arrange about essential food supplies, and at the close of the war he was asked by the League of Nations to go to Russia to arrange about the repatriation of prisoners of war. Into this and allied humanitarian work Nansen threw himself heart and soul, as was his way in all he did. He was Norway's representative on the League of Nations in whose meetings he took a leading part. In 1921–23 he was busy on behalf of the Red Cross in the relief of famine in Russia and refugees in Armenia. The generous help that was forthcoming from America on that

occasion was in great measure due to the prestige of Nansen's name. In 1922 he was awarded the Nobel Peace Prize.

In spite of all these new activities Nansen never lost his interest in polar affairs. His wise counsel was sought by many and never sought in vain, and his mind was ever youthful and open to new ideas. A measure of his success as a polar traveller had been due to his use of new equipment: ski, light sledges, kayaks, aluminium cookers, and fresh food, and he was quick to see the added gains that new inventions afforded. He saw at once the value of aviation for polar transport and was the founder and first President of the International Society for the Exploration of the Arctic by means of Aircraft. He had hoped to make an Arctic journey in the *Graf Zeppelin* this summer (see *G.J.*, 75, 1930, pp. 67–70).

Nansen was a fluent writer, and his skill as an artist can be seen in the illustrations of many of his books. In addition to the works mentioned his books include: 'The First Crossing of Greenland,' 1890; 'Farthest North,' 1897; 'Through Siberia,' 1914; 'En Ferd til Spitsbergen,' 1920; 'Hunting and Adventure in the Arctic,' 1925; 'Sporting Days in Wild Norway,' 1925. 'Adventure and other papers' (1927) includes the address which Nansen delivered in 1920 as Lord Rector of the University of St. Andrews. It contains a frank account of youthful ambitions, early difficulties, and the spirit to which he attributed his achievement and success.

In many polar lands, north and south, the name of Nansen has been attached to geographical features; but he needs no such memorials. The thoroughness of his work gave it lasting value, and he has gained an honoured place among the ranks of polar travellers and scientists. In other places his work for the League of Nations and in the cause of international goodwill may be more fittingly appraised. Here it must suffice to say that to Nansen these efforts were even more important than his scientific work. He died at his home at Lysaker on 13 May 1930.

R. N. Rudmose Brown.

HENRY NEWTON STEVENS

We regret to record the death, on April 26, after a somewhat protracted illness, of Mr. Henry N. Stevens, head of a firm of well-known American booksellers, who had been a Fellow of this Society since 1906. Son of Henry Stevens of Vermont, a keen student of all literature relating to America, he was born in London in 1855. His mother, whose maiden name was Newton, had been first married to Count Kuczynski. He was educated partly at a school in this country, partly in the United States, and entered the business of his uncle, Benjamin Franklin Stevens, afterwards working for the Chiswick Press till about 1884. He then joined his father, becoming partner with him the next year, and head of the firm on the latter's death in 1886. He took keenly to his father's pursuits in American bibliography, of which his knowledge was almost unrivalled, paying especial attention to the cartographical history, many of the greatest rarities in this field having passed through his hands in course of time. Many years before his death his father had started making a collection of the various editions of Ptolemy's geography, and this was extended by the son as a memorial to his father until it was probably the most complete in existence, becoming eventually the property of Mr. Edward E. Ayer of Chicago. Mr. Stevens compiled a descriptive handbook to this collection, which was first issued in an édition de luxe, including a set of the sixty book-plates prepared for insertion in the several volumes, and subsequently reprinted for more general use (1908). In 1905 he wrote a monograph on the complicated history of the famous Lewis Evans map

of the British Colonies in America (see *Journal*, 26, p. 334), a second edition appearing in 1920. Among the rarities which he had brought to light was a variant of the much-discussed map in the Ptolemy of 1513, which he held to have been originally prepared some years earlier and to have been the first to bear the name America. In support of this thesis he brought out a well-produced memoir in 1928 (see *Journal*, 74, pp. 75–77), but his conclusions were contested by some critics. His latest essay in literature was the work entitled 'New Light on the Discovery of Australia,' in which he printed various documents bearing on the Voyage of De Quiros, the most important being a previously unknown Journal (secured by him at a sale at Sotheby's a few years before) of Don Diego de Prado, by whom the voyage was continued after the return of the original leader. The subject was again a controversial one, but whatever view may be taken of the theories put forward, the work is an important contribution to the history of early voyages.

In 1923 Mr. Stevens was a guest at the opening of the Clements Library at Ann Arbor, Michigan, receiving the honorary degree of M.A. at the University there in recognition of his work in geographical-bibliographical research. He was also an honorary member of the American Antiquarian Society.

The family is now represented in the firm by a third Henry Stevens, son of the subject of this notice, who became a partner with his father and Mr. R. E. Stiles in 1907.

MEETINGS: SESSION 1929–1930

Fourteenth Evening Meeting, 2 June 1930. The President in the Chair

Paper: A Journey in the Rub' al Khali. By Mr. Bertram Thomas. (Read for the author by Sir Arnold Wilson)

Elections: Prof. Ardito Desio; A. H. Hollister, J.P.; Mrs. F. A. Hollway; Mrs. Lucy Hotz; Stanley Percival Jackson, B.A.; Miss Annie Bertha Jolly; Dr. Werner Kissling; Alexander Wallace Leitch; Jack Morris; The Lord Moyniham; C. A. Willans

Fifteenth Evening Meeting, 16 June 1930. The President in the Chair

Paper: The Geography of Petra and Edom. By Mr. George Horsfield. (Read for the author by Miss Agnes Conway)

Elections: Bernard Meredith Allen, M.A., LL.D.; J. Walker Barlett; Percy Mayson Bennett, M.I.E.E., A.M.I.MECH.E.; John George Bucher; Sir Aldo Castellani, K.C.M.G., F.R.C.P.; George Courtauld; Miss Emily Rebecca Ashwood Crossley; R. H. Denniss; Miss Edith Drummond; Sydney Fawns, M.I.M.M.; Mrs. Ellen Forsyth; John Morgan Richard Francis; George Corning Fraser, B.S., LL.B.; The Rev. Frank Gardner; Ralph Murray Greg, M.A.; General Sir Richard Haking, G.B.E., K.C.B., K.C.M.G.; Caleb Dean Hammond; His Hon. Judge Howay, LL.B.; Leonard Howes; Kanichi Kokubu; Robert Humphrey Marten, M.D., M.R.C.S., L.R.C.P.; K. Mackintosh Robertson, M.A.; Miss Elizabeth Sharpe, F.B.E.E., F.R.E.S.; James Michael Slemmen; John Sperni; Mrs. Winifred Mary Stevens; Lt.-Col. William Atkinson Stott; The Rev. C. W. Thorne, M.A.; Ernest Walker

Diagrams to

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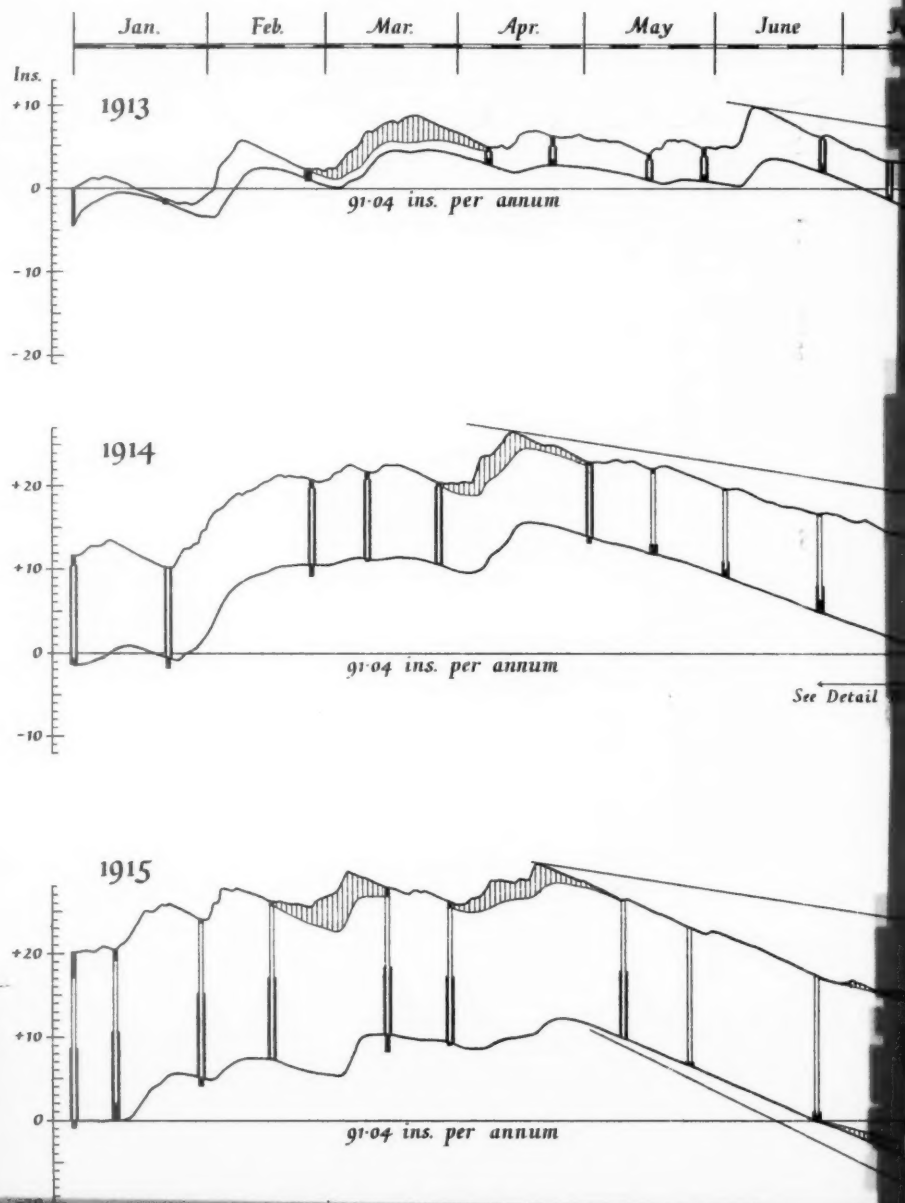
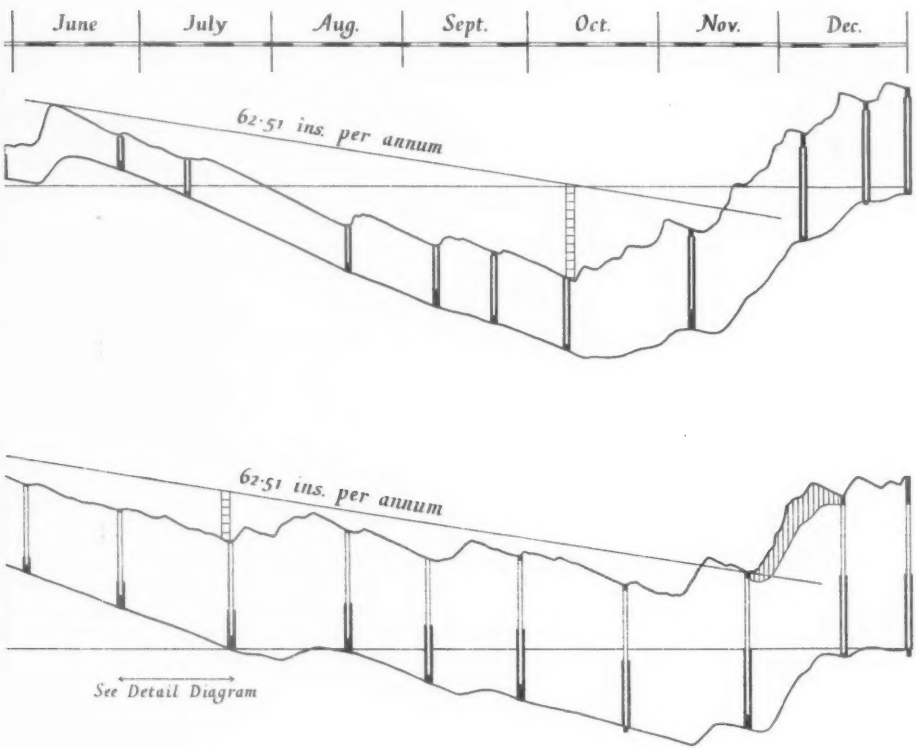
Deficiency from the Aggregate of the Average Rainfal

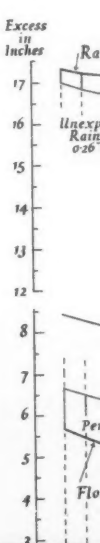


rams to accompany the paper on RIVER-FLOW

by W. N. McClean, A.M. Inst. C.E.

Aggregate Rainfall and Flow-off shown as an Excess or erage Rainfall Rate of the 3 years. (91·04 inches per annum.)





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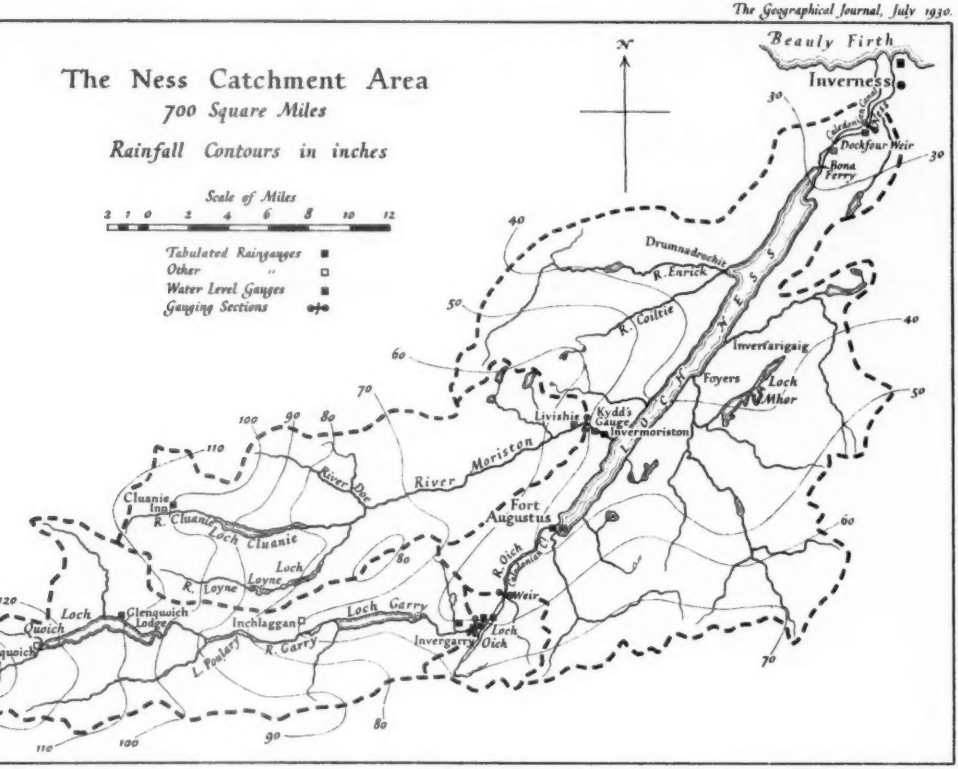
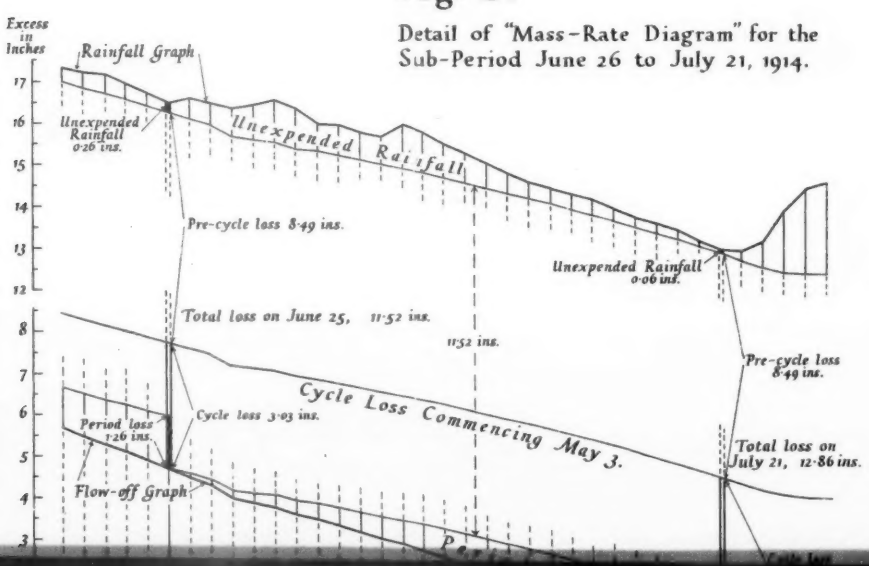
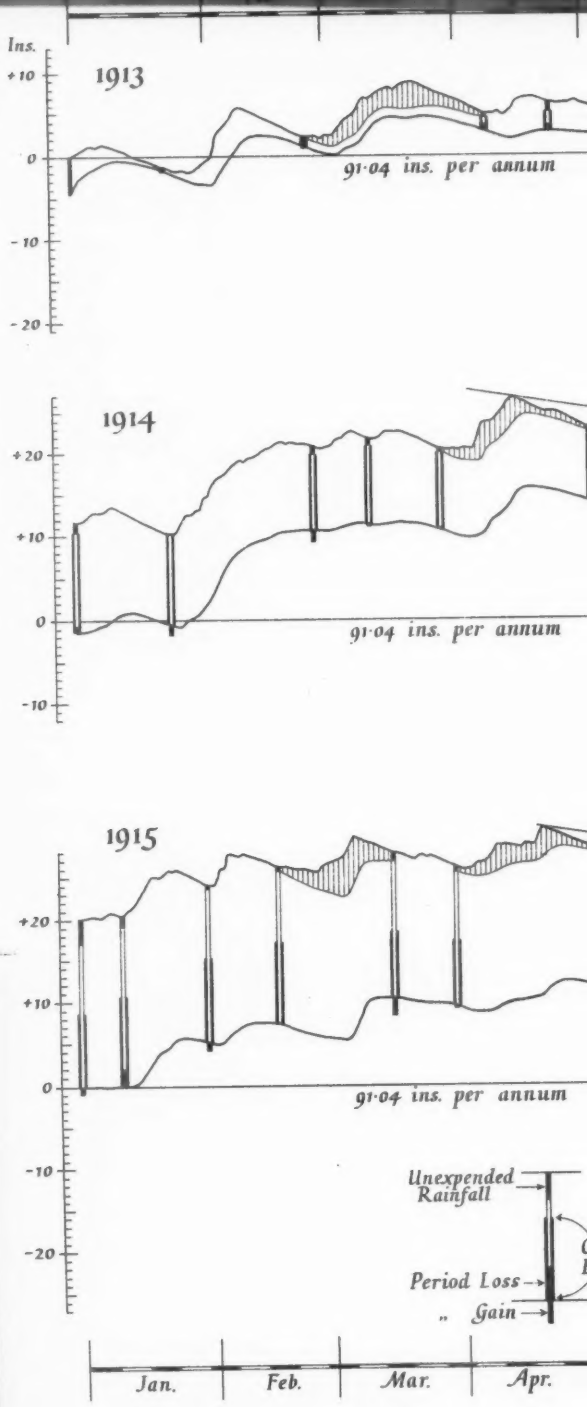


Fig. 2.

Detail of "Mass-Rate Diagram" for the Sub-Period June 26 to July 21, 1914.

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Unexpended Rainfall
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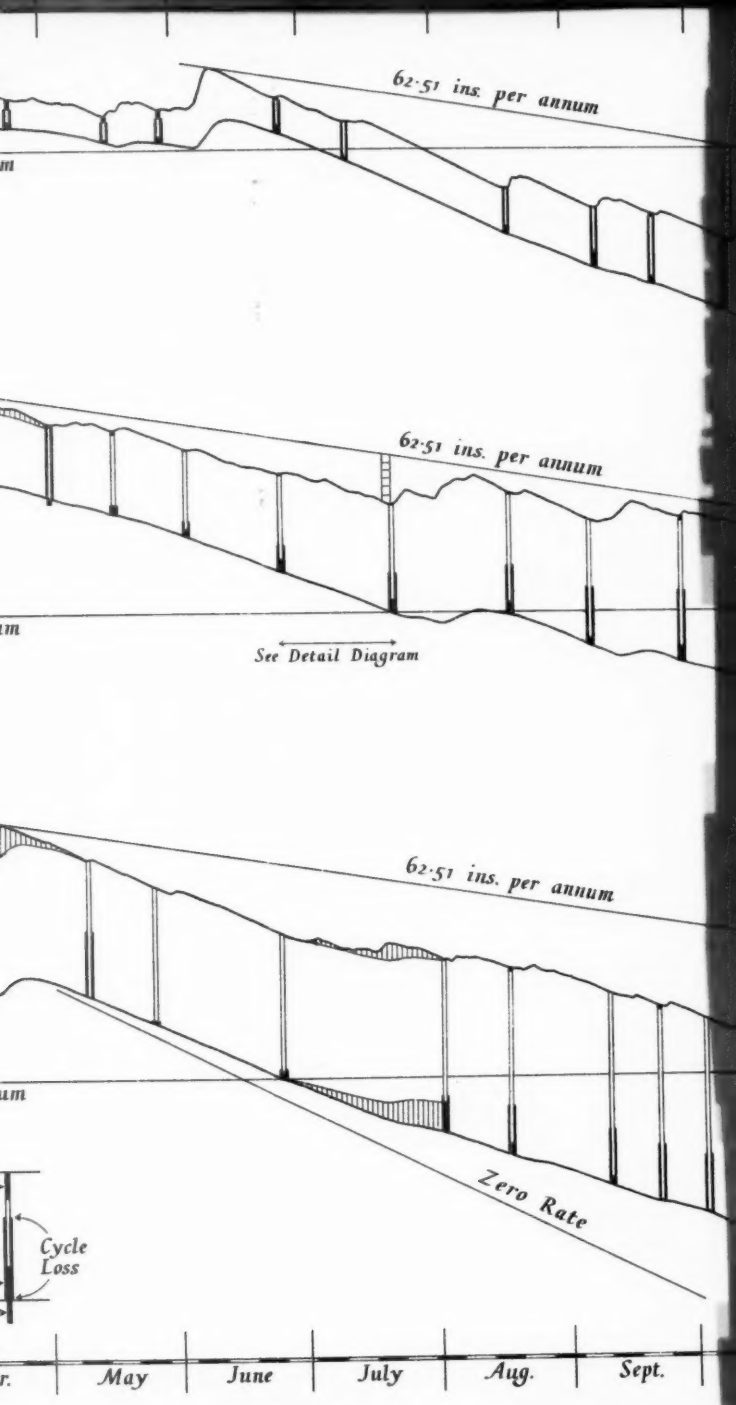
62·51 ins. per annum
62·51 ins. per annum
See Detail Diagram
62·51 ins. per annum
Zero Rate
Cycle Loss
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June
July
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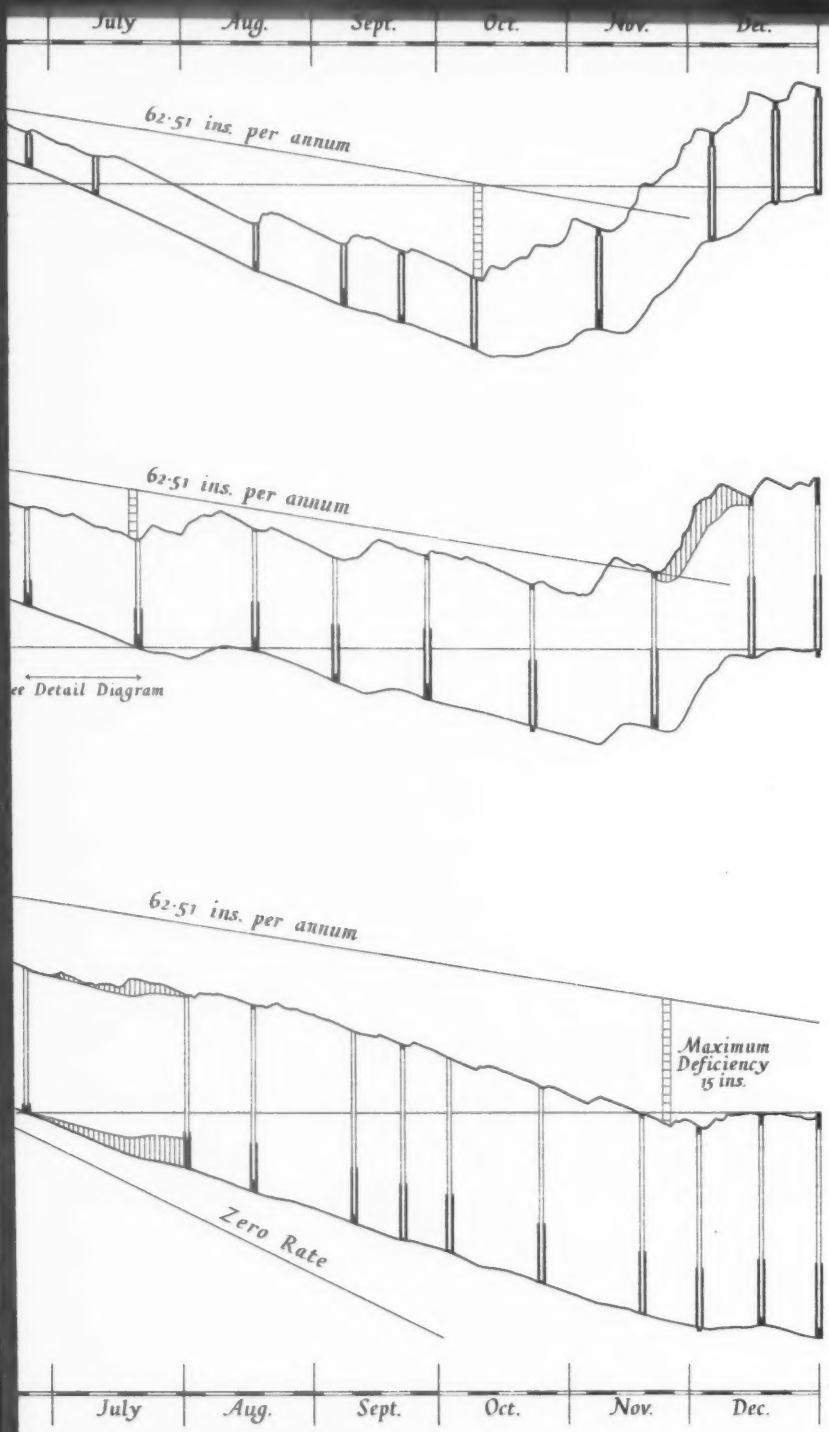
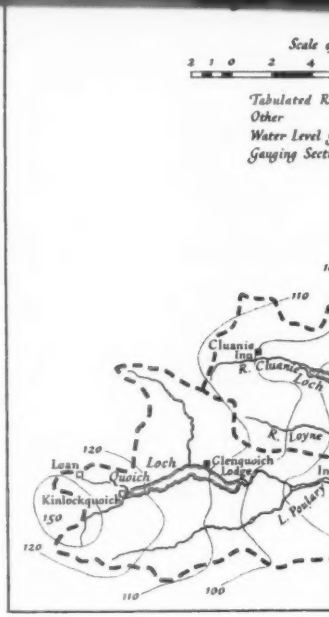
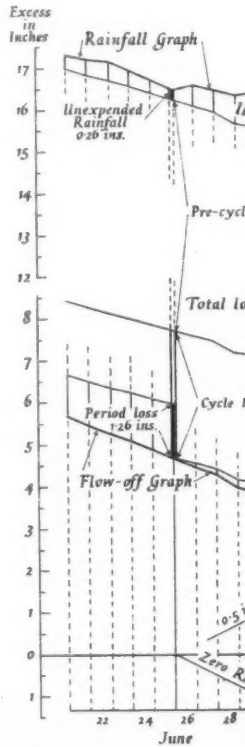
Fig. 1.







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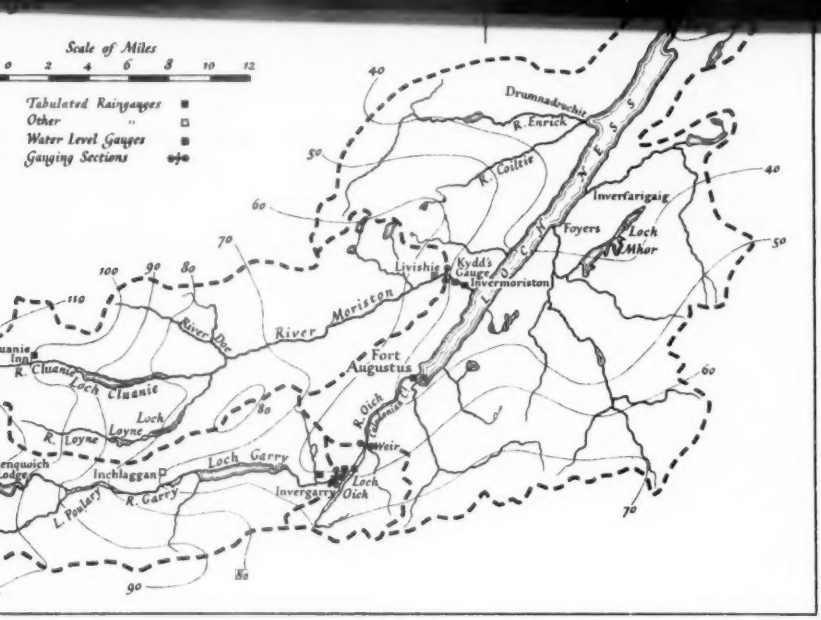

Fig. 2.

Detail of "Mass-Rate Diagram" for the Sub-Period June 26 to July 21, 1914.

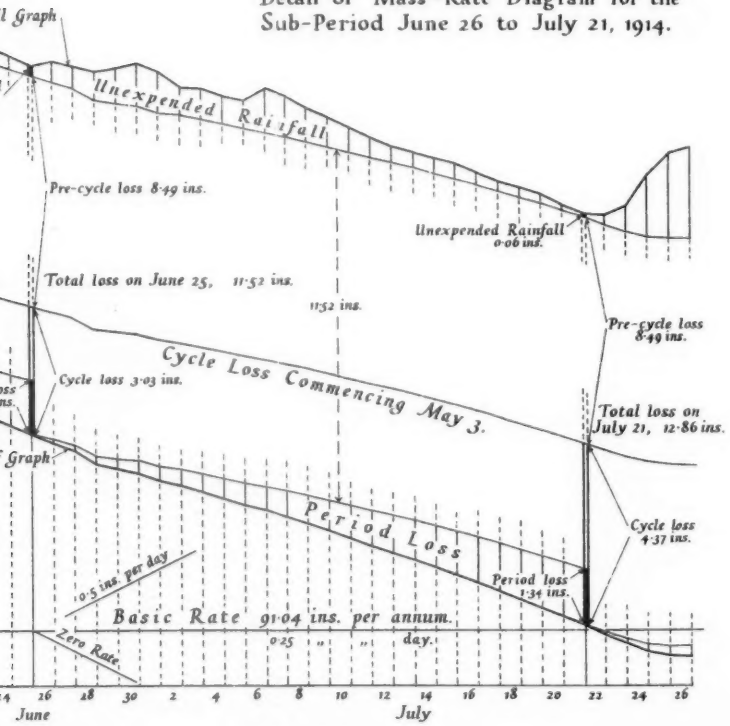
Unexpended Rainfall
Pre-cycle loss 8·49 ins.
Unexpended Rainfall 0·06 ins.
Total loss on June 25, 11·52 ins.
11·52 ins.
Pre-cycle loss 8·49 ins.
Cycle Loss Commencing May 3.
Cycle loss 3·03 ins.
Total loss on July 21, 12·86 ins.
Period Loss
Cycle loss 4·37 ins.
Period loss 1·34 ins.
0·5 ins. per day
Basic Rate 91·04 ins. per annum.
0·25 " " day.
Zero Rate.
24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26
June
July

Fig. 3.